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**Characterization and Source Apportionment of Regional Background
Inhalable Particulate Matter in Alberta**

by

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The undersigned certify that they have read, and recommend to the Faculty of Graduate Studies and Research for acceptance, a thesis entitled **Characterization and Source Apportionment of Regional Background Inhalable Particulate Matter in Alberta** submitted by **Jason Lee Schulz** in partial fulfillment of the requirements for the degree of Master of Science in Environmental Science.

ABSTRACT

This study undertook air sampling, elemental and morphological analysis, and source apportionment receptor modeling for ambient particulate matter with an aerodynamic diameter of 10 micrometers or less (PM_{10}) at a representative site in Devon, Alberta over a two-month period (August and October 2000). The goal was to determine the level, chemical composition and morphology, and sources of regional background PM_{10} at this location. Measurements taken using a Tapered Element Oscillating Microbalance (TEOM) showed that the 24-hour average PM_{10} levels over the entire sampling period had a mean of 13 $\mu g/m^3$ and were significantly higher in October. Samples collected using an Airmetrics Minivolume Portable Survey Sampler (MiniVol) and subsequently analyzed using a Scanning Electron Microscope with Energy Dispersive X-Ray (SEM-EDX) were dominated by lithophilic elements (Si, Ca, Fe, Al, K and Mg) and biological material. Receptor modeling utilizing principle component analysis (PCA) apportioned PM_{10} collected to four main source categories that combined to account for 86% of total variance of the original data set. The largest contribution came from crustal material sources (30%) followed by coal emissions (22%), combustion sources (18%) and regional sulphate (15%).

ACKNOWLEDMENTS

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

CHAPTER 1: INTRODUCTION

1.1   Background

Airborne particulate matter is an environmental contaminant that is unique among air pollutants. Elevated levels of particulate matter are abundantly evident. People do not need to be told there is a problem, they can see and taste it. Particulate matter is a generic term for a broad class of substances of varying size and chemical composition that are transported in the air as discrete solid particles or liquid droplets. The amount, size and chemical composition of particles can differ from location to location and over time, depending on the types of source emissions and atmospheric conditions.

Concern about airborne particulate matter in recent years has been largely driven by epidemiological studies that have reported relatively consistent links between ambient particulate matter levels and adverse health effects (NRC, 1998). These and other scientific studies led the United States Environmental Protection Agency (U.S. EPA) to announce revised National Ambient Air Quality Standards (NAAQS) for particulate matter with aerodynamic diameters less than or equal to 10 μm (PM_{10}) and 2.5 μm ($PM_{2.5}$) in July 1997 (U.S. EPA, 1997). The Government of Canada, in cooperation with the provincial and territorial governments, followed suit by ratifying a Canada-wide Standard (CWS) for $PM_{2.5}$ in June 2000 (CCME, 2000). In addition, serious consideration is being given to implementing a CWS for PM_{10} in the future (CCME, 2000).

Development of particulate matter control programs by government and industry and evaluation of their effectiveness as new standards and sources are introduced, necessitates an accurate understanding of the chemical and physical properties of particulate matter, its origins, and the contribution of each source to particulate matter levels. This understanding begins with ambient monitoring and sampling programs designed to complement studies of urban air quality with observations of regional background air quality. Without this knowledge it is difficult, if not impossible, to judge how much net impact anthropogenic activities are having on the quality of air we breathe. Regional background particulate matter is generally defined as the distribution of particulate matter concentrations as observed in the absence of local anthropogenic point source emissions, but still under the influence of local open and natural sources and from the long-range transport of anthropogenic particles and precursor gases. Ambient monitoring and sampling programs for regional background areas are necessary for a number of reasons (Munn, 1981):

- so that regional background loadings can be subtracted from measured urban and industrial concentrations when pollution models are being validated;

- to separate the effects of long-term changes in emissions from changes in climate; and

- for public relations purposes and to provide citizens with urban-regional air quality comparisons.

Studies concerning levels, chemical composition and morphology, and sources of regional background PM_{10} in the atmosphere have been conspicuously lacking from the literature. One reason for this disparity is that it is becoming increasingly difficult to locate areas that are not under some degree of influence from local anthropogenic point source emissions. However, this does not mean that studies designed and conducted to determine the characteristics and sources of regional background particulate matter should be avoided. Rural sites located near the urban areas where the information will be used can provide an adequate estimate of regional background particulate matter characteristics. This includes the measurement and characterization of particulate matter from open sources and from long-range transport of anthropogenic particles and precursor gases in the same geographical region (Munn, 1981).

Such studies involving the collection of information regarding regional background PM_{10} from Alberta are absent and are of prime importance in regional air pollution health effects studies and regulatory assessment. These types of studies are needed in Canada, and especially Alberta, more than ever with the announcement of the previously mentioned CWS for particulate matter (CCME, 2000). Among some of the issues the standard addresses are those directly involving regional background particulate matter. The standard states, for example, that "communities for which jurisdictions demonstrate that continued exceedance of the CWS levels is primarily due to…regional particulate matter and that best efforts have been made to reduce contributions to the excess levels from pollution sources within the jurisdiction, will be identified in reporting as "communities influenced by background or natural

3

events" (CCME, 2000)." This clause permits a community that is invariably reporting particulate matter levels beyond those allowed due to regional background influences to exceed the standard without penalty. However, "demonstration of background or natural influence is the (sole) responsibility of the affected jurisdiction (CCME, 2000)." The trouble is that there are very few studies concerning the characteristics and sources of regional background PM_{10} in Canada and, until this study, none in Alberta, from which these jurisdictions can draw any conclusions about the influence of regional background particulate matter. Studies concerning the characteristics and sources of regional PM_{10} in Alberta are, therefore, required to assist communities in determining the impact that pollution is having on their daily lives.

1.2   Objectives

The primary purpose of this study was to establish the regional background level of PM_{10} in Alberta, characterize its chemical composition and morphology, and trace its origins using a receptor-based analysis method. The broad goal was to develop an enhanced foundation of information regarding the characteristics and sources of inhalable particulate matter in a rural community that is without major local anthropogenic point source emissions, but still under the influence of local open and natural sources and from the long-range transport of anthropogenic particles and precursor gases. In other words, the goal was to fill a gap in the current literature regarding the characteristics and sources of regional background particulate matter in Alberta. The specific objectives of the study were:

- to determine the ambient levels of the PM_{10} in a regional background community, explore any seasonal variation, evaluate meteorological impacts, and compare the results with those of similar studies and current regulations;

- to ascertain the elemental composition and morphology of the PM_{10} in a regional background community, explore any seasonal variation, and evaluate meteorological impacts; and

- to establish the sources of the PM_{10} in a regional background community and evaluate their contributions to overall levels.

The results of this study can be used to evaluate existing emission reduction strategies for ambient particulate matter levels, to devise more efficient emission reduction strategies for ambient particulate matter levels for industry and government, and to provide the necessary information for the development of particulate matter guidelines. In general, this study can equip society with an improved foundation upon which to make decisions about managing air quality issues that can have a maximum benefit to society. Better information about the levels, chemical composition and morphology, and source contributions to particulate matter in regional background settings can lead to a better basis for managing health, environmental and public welfare impacts of anthropogenic activities.

1.3   Overview

The objectives of this study were accomplished by judgmentally selecting a representative site in a rural Albertan community which had minimal local anthropogenic point source emissions of particulate matter, but which was still under the influence of local open and natural sources, in addition to regional source emissions from industrial activities and large urban centers. The community selected was Devon, Alberta (Figure 1). Devon is a small, centrally located rural community with a population of about 5,000. It has no significant local industrial point source emissions of particulate matter, but it has potential open sources such as construction and agricultural activity. It is located approximately 30 km southwest of a large urban center (Edmonton, Alberta) and about 50 km east and southeast of a number of industrial point sources (i.e. coal fired power plants). Due to these characteristics, Devon was an ideal candidate community to execute a study to determine the characteristics and sources of regional background PM_{10} in Alberta.

An air-sampling program was performed that involved two 22-day sampling periods spread over two seasons to account for seasonal, meteorological and human activity variability. A Tapered Element Oscillating Microbalance (TEOM) was used to continuously measure PM_{10} levels, and an Airmetrics Minivolume Portable Survey Sampler (MiniVol) was used to collect PM_{10} filter samples. Laboratory work involved Scanning Electron Microscopy with Energy Dispersive X-Ray (SEM-EDX) analysis to establish the elemental composition and morphology of the PM_{10} samples. From the measurements obtained, a receptor model utilizing principle component analysis

(PCA) was performed to determine the most likely elemental profiles of the sources. These elemental profiles were then compared to the results of previous studies, to relevant literature, and to particulate matter databases (including the U.S. Environmental Protection Agency's SPECIATE database (U.S. EPA, 1993)) to identify and categorize the most likely sources of PM_{10} at the receptor location.
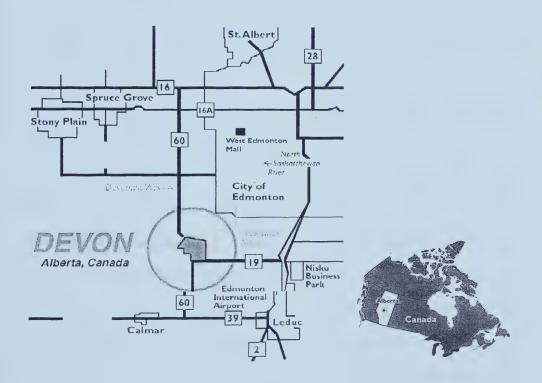
Figure 1. Location of Devon, Alberta.

1.4   Thesis Organization

In this thesis, the next chapter (Chapter 2) provides a summary of relevant literature, including discussions on the characteristics of particulate matter (size, sources, chemical composition and ambient levels); the various impacts of particulate matter (health, environmental and public welfare) and a summary of current standards applied to mitigate those impacts; the various types of receptor models in use (chemical mass balances and multivariate techniques) and the source elemental abundance profiles that they apply; and, finally, a review of particulate matter studies done to date in Alberta. Chapter 3 describes the criteria used to select a study area, a description of the study area (Devon, Alberta), and an account of the air quality in the study area. The specific details of sample collection, sample analysis, data analysis, and quality control and assessment, as performed in this study, are presented in Chapter 4. Chapter 5 constitutes a presentation and discussion of the results obtained in this study including: PM_{10} levels, PM_{10} chemical composition and morphology, and PM_{10} source apportionment. This chapter also reports on the seasonal differences, effects of meteorology, and a comparison of the results to similar studies and current regulations. Conclusions and recommendations are presented in Chapter 6. References are listed in Chapter 7 and Chapter 8 contains the various appendices (Field Data Log Forms, TEOM Raw Data, Meteorological Data, Raw Chemical Composition Data, and SEM Photographs and EDX Spectra).

CHAPTER 2: LITERATURE REVIEW

2.1   Particles in the Atmosphere

2.1.1   Introduction

Particulate matter refers to all airborne liquid and solid particles that are microscopic in size (WGAQOG, 1998). The physical and chemical characteristics of particulate matter are intricate, reflecting a multitude of natural and anthropogenic sources and the fact that particles are constantly evolving as they interact with other components of the atmosphere. Given this complexity, it is useful to categorize particulate matter on the basis of three important features: particle size, sources and chemical composition. These features, along with such factors as meteorology and local topography, combine to dictate the ambient levels of particulate matter.

2.1.2   Particle Size

Particle size is perhaps the most critical parameter for characterizing the behavior and origin of particulate matter. The chemical composition, fate, transport, removal and residence time of particulate matter in the atmosphere are all related to particle size. The way in which particle size is most often measured is the micrometer (μm), which is 10^{-6} m. Although atmospheric particles are often not spherical, particle size usually refers to the particle aerodynamic diameter. The aerodynamic diameter, D_a, depends on particle density and is defined as the diameter of a spherical particle with equal settling velocity but a material density of 1 g/cm^3 (U.S.

EPA, 1996). Particles with the same physical size and shape but different densities will have different aerodynamic diameters. Figure 2 illustrates the idealized size distribution of particulate matter in ambient air (U.S. EPA, 1996).
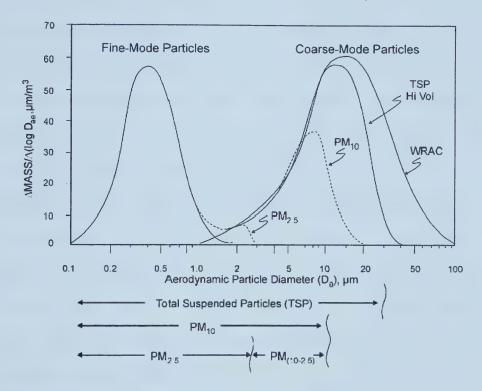
Figure 2. Idealized Size Distribution of Particulate Matter Showing Fine and Coarse Modes, the Portion Collected by Various Samplers, and the Overlap of $PM_{2.5}$ and the Coarse Fraction of PM_{10} (adapted from U.S. EPA, 1996).

Most concern arises with the suspended portion of particulate matter in the ambient air, which generally covers the size range up to 40 μm. These particles are known as total suspended particulate (TSP). The smaller ambient particles have a characteristic mass distribution that results in their being considered as two major classes: coarse particulate matter (2.5 μm to 10 μm) and fine particulate matter (≤ 2.5 μm). Common terminology uses PM_{10} to refer to all particles less than or equal to 10

10

μm in diameter and $PM_{2.5}$ to refer to particles less than or equal to 2.5 μm in diameter (WGAQOG, 1998).

Particle size may vary from approximately 0.005 μm to 100 μm in aerodynamic diameter. The particle size range from 0.005 μm to 0.1 μm is known as the ultrafine mode. These particles have relatively short residence times in the atmosphere because they rapidly coagulate with larger particles or serve as nuclei for cloud or fog droplets. The size range from 0.1 μm to 2.5 μm is known as the accumulation or fine mode. Fine particles are, in general, too small to settle out by gravity and too large to coagulate into larger particles, and thus they have lifetimes in the atmosphere in the order of days and can be transported over long distances. Particles in the size range from 2.5 μm to 100 μm are referred to as coarse particles. They are relatively large, settle out of the atmosphere by gravity within hours or minutes, and are only found near the source depending on height of release (Koutrakis and Sioutas, 1996).

2.1.3   Sources

Particulate matter is a ubiquitous pollutant, reflecting the fact that it has both natural and anthropogenic (occurring from human activates) sources (WGAQOG, 1998). Natural sources of particulate matter include windblown soil and mineral particles, meteor dust, volcanic dust, sea salt spray, debris from wildfires, and biological material such as pollen, spores and bacteria (U.S. EPA, 1996). Normally, these natural sources produce coarse particles, although some high temperature

11

combustion sources such as wildfires will generate fine particulate matter (WGAQOG, 1998). Anthropogenic sources produce both coarse and fine particles. Sources that produce primarily coarse anthropogenic particulate matter include agricultural activities, dust from roads and some industrial activities such as cement manufacturing, mining, smelting and construction (Cooper and Watson, 1980; Cheng et al., 1998). Smaller particles of more complex chemical composition are generated through many industrial activities and through combustion activities in electrical power plants (oil, coal and gas), automobiles, industrial boilers, biomass burning, refuse burning and residential wood burning (WGAQOG, 1998).

Another distinction of importance is between those particles that are emitted directly into the atmosphere (primary particle), as opposed to those that are formed in the atmosphere from gaseous emissions (secondary particles). Primary particles are formed as a result of physical or mechanical processes such as crushing, grinding and erosion that lead to the physical breakdown of larger particles into smaller ones (Environment Canada and Health Canada, 2000). Not surprisingly, particles formed in this manner are primarily coarse. Primary particles are also emitted directly form combustion sources that usually produce fine particles (WGAQOG, 1998).

Secondary particles are formed through chemical reactions in the atmosphere involving gas-to-particle conversion processes. Particles formed in this fashion are most often fine particles. The most frequent precursor gases involved in these reactions are nitrogen oxides (NO_x), sulphur dioxide (SO_2), volatile organic compounds (VOC) and ammonia (NH_3), which form particle sulphate and nitrate (often in the form of ammonium sulphate and nitrate) and numerous organic carbon

12

compounds (WGAQOG, 1998). All of these precursor gases are emitted during the combustion of fossil fuels and as a result of several other industrial processes. Volatile heavy metals are also emitted in vapour form during combustion and other high temperature combustion processes. These can condense in the atmosphere to form fine particles (U.S. EPA, 1996). Table 1 summarizes the natural and anthropogenic sources for the major primary and secondary particulate matter constituents of fine ($PM_{2.5}$) and coarse (PM_{10}) particles (U.S. EPA, 1996; Environment Canada and Health Canada, 2000).

Table 1. Sources of Particulate Matter (U.S. EPA, 1996; Environment Canada and Health Canada, 2000).

Natural		Anthropogenic	
Primary	**Secondary**	**Primary**	**Secondary**
PM_{10} • Windblown dust • Sea salt spray • Pollen and spores	**PM_{10}** • None	**PM_{10}** • Agricultural • Construction • Road Dust • Mining	**PM_{10}** • None
$PM_{2.5}$ • Wildfires • Sea salt spray • Volcanic activity • Viruses and bacteria	**$PM_{2.5}$** • Organic carbons from biogenic VOCs • Nitrates from natural NO_x • Natural NH_3	**$PM_{2.5}$** • Fossil fuel combustion • Vehicle exhaust • Industrial activates • Wood combustion	**$PM_{2.5}$** • Organic carbons and NH_3 from human activates • Sulphates and nitrates from human sources of SO_2 and NO_x

Sources of PM_{10} are usually associated with primary emissions with inventories dominated by fugitive dust sources (both natural and anthropogenic). These fugitive dust sources were estimated to contribute approximately 89% of the

United States total, however the geological material varies greatly from site to site. As a result, levels have been seen to vary from 20% to 80% (Chow and Watson, 1998). For Alberta, the fugitive dust found in the coarse particles ranged from approximately 55% to 65% (Cheng et al., 1998).

Sources of $PM_{2.5}$ can be broken into three emission types: primary solid (emitted directly in solid phase), primary condensable (emitted in gas phase and then condenses into solid phase) and secondary (formed by atmospheric reactions). The primary emission sources include gasoline, diesel, wood stoves, fireplaces, land clearing, agricultural prescribed burning, wild fires, paved and unpaved roads, dust from ore processing, construction, agriculture, wind erosion (7% to 8% in Alberta), compressor stations, gas processing plants, power plants, incinerators and furnaces (Pryor and Barthelmine, 1996; U.S. EPA, 1996; Cheng et al., 1998; Chow and Watson, 1998). The secondary emissions include sulphates, nitrates and organic aerosols formed from primary gaseous emissions (U.S. EPA, 1996).

Current estimates of the magnitude of actual primary emission sources in Canada reveal that open sources (i.e. road dust, agricultural activates, wind erosion, construction and mining) are the major sources of both fine and coarse primary anthropogenic particulate matter in Canada, a condition that poses a challenge in terms of control policies (WGAQOG, 1998). In Alberta, it has been estimated that primary open sources contribute approximately fifty-five times more to particulate matter levels than do industrial point sources (Cheng et al., 1998). The contributions from secondary particulate matter sources are much more difficult to predict and precise estimates are not available.

2.1.4 Particle Chemical Composition

As a consequence of their different mechanisms of production and sources, fine and coarse particles have much different chemical compositions as shown in Figure 3 (Environment Canada and Health Canada, 2000). Coarse particles consist primarily of particles derived from the earth's crust material and are therefore enriched in iron, calcium, silicon and aluminum and are typically basic in nature (U.S. EPA, 1996). Particles from coastal regions are enriched with sodium and chlorine from sea salt. Fine particles are composed mainly of sulphate, nitrate, ammonium, inorganic and organic carbon compounds, and heavy metals such as lead and cadmium, all of which are indicators of anthropogenic production processes. Sulphate (SO_4^{2-}) has repeatedly been shown to be the single most plentiful component of fine particles (WGAQOG, 1998).

PM≤10
Iron
Calcium
Silicon
Sodium
Chlorine
Aluminum

PM≤2.5
Sulphate
Nitrate
Ammonium
Lead
Cadmium
Organic Carbon

Precursor Gases:
Sulphur Dioxide
Nitrogen Dioxide
Volatile Organic Compounds
Ammonia
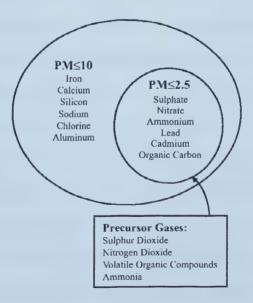
Figure 3. Generalized Chemical Composition of Particulate Matter (adapted from Environment Canada and Health Canada, 2000).

2.1.5   Ambient Levels

Ambient levels of particulate matter at sites across Canada and the world are affected by a number of factors, including local sources of particulate matter, long-range transport, meteorological conditions, and topographical and other physical features, such as the proximity of mountains, lakes and oceans (WGAQOG, 1998). As a result, particulate matter levels vary with season, with time of day, and from site to site. Even within a city or region there can be marked differences in particulate matter characteristics. Even though particulate matter is a problem in urban areas, it is not exclusively so. As a general rule, where local sources are significant, where long-range transport is significant, and/or where topographical and meteorological conditions hinder the dispersion of pollutants, elevated levels of particulate matter can be expected (WGAQOG, 1998).

Particulate matter can be monitored in many different types of areas. Generally, these areas can be divided into three key groups: remote background (natural), regional background and urban (or industrial). Remote background areas are considered to be under the influence of only natural sources of particulate matter and therefore contain levels of particulate matter that would be detected in the absence of anthropogenic sources (U.S. EPA, 1996). Examples of absolute background areas include Antarctica, Greenland or over an ocean. It is difficult to ascertain the exact magnitude of background concentrations of particulate matter, since even remote areas can be impacted by long-range transport of anthropogenic emissions. With this in mind, background concentrations of PM_{10} have been

estimated to fall in the range of 4-12 $\mu g/m^3$ (micrograms per cubic meter) for a 24-hour average and for $PM_{2.5}$ in the range of 1-5 $\mu g/m^3$ for remote regions of North America (Environment Canada and Health Canada, 2000). Regional background areas differ from remote background areas in that they can contain not only influences from natural sources, but also anthropogenic open sources and long-range transported emissions (anthropogenic and natural). It is difficult to judge the exact magnitude of particulate matter levels in regional background areas as the levels can vary dramatically from region to region. However, levels can range from 15-30 $\mu g/m^3$ (U.S. EPA, 1996). Urban (or industrial) areas clearly include any region that is affected by all types of particulate matter emissions, including local industrial point sources. Again, the levels of particulate matter in these areas can vary widely. Levels have been shown to be as low as 10 $\mu g/m^3$ and as high as 100 $\mu g/m^3$ (U.S. EPA, 1996).

2.2   Effects Characterization

2.2.1   Introduction

Much of the concern about particulate matter in the atmosphere arises because particles of certain size ranges can be inhaled and retained by the human respiratory system where they can create serious health problems. Yet, health effects, while the most significant for humans, are not the only manner in which particulate matter can adversely impact our world. There is also worry about the harmful influence of particulate matter on the environment and public welfare. These impacts can be and usually are mitigated in many jurisdictions by the setting of various standards and regulations.

2.2.2   Health Effects

Studies on the potential adverse effects of particulate matter on human health began in earnest in the late 1980's and early 1990's (Bates et al., 1990; Ostro et al., 1991; Dockery et al., 1992, 1993; Thurston et al., 1992; Roemer et al., 1993; Schwartz et al., 1993; Burnett et al., 1995; Pope et al., 1995). These and numerous other epidemiological studies were performed in an attempt to establish causal relationships between particulate matter concentrations measured in ambient air and endpoints such as increases in morbidity, mortality and a variety of specific respiratory symptoms (e.g. asthma, bronchitis and decreased respiratory flow rates). A comparison and complete reference list of the major studies performed is presented in the Air & Waste Management Association's 1997 Critical Review of

Ambient Particles and Health: Lines that Divide (Vedal, 1997). Several of the conclusions reached by the review include:

- there remains a basic disagreement between the interpretation of epidemiological data and the health effects associated with increases in particle air pollution;

- observed particle health effects have persisted despite attempts to control for potentially confounding meteorological effects;

- sources of error, in particular measurement error at the individual level, results in biased epidemiological results;

- issues such as confounding and bias increase the concerns about determining the biological plausibility (the actual toxic mechanism) by which particles exert their adverse health effects;

- conflicting results from European studies that do not coincide with findings in the U.S.;

- difficulties exist in establishing a link between particle size and health effects;

- there remains a lack of sufficient evidence to assign significance to the acid aerosol component; and

- there remains uncertainty associated with the ambient concentrations of fine particle fraction (less than 2.5 μm aerodynamic diameter) and any potential toxicity/pathogenicity.

Although many of these issues still remain unresolved and are the topics of current debate, Canada has seen fit to declare ambient particulate matter a pollutant

of concern and has taken action early in an attempt to protect human health (Environment Canada and Health Canada, 2000):

> Based principally on the sufficient weight of evidence of mortality and morbidity in the general population exposed to ambient concentrations of PM_{10} and $PM_{2.5}$ examined in recent epidemiological analyses in Canada and in other countries (at ambient concentrations currently occurring in Canada), as well as on some limited supporting data in experimental animal and controlled human exposure studies, PM_{10} and particularly $PM_{2.5}$ are considered to be entering the environment in a quantity or concentration or under conditions that constitute or may constitute a danger in Canada to human life or health. Therefore, PM_{10} and particularly $PM_{2.5}$ are considered to be toxic as defined in Section 64 of the Canadian Environmental Protection Act, 1999.

The following is a discussion of some of the direct and indirect pathways that are important for particulate matter to exert its potential adverse toxic effects on human health. The respiratory mechanisms by which individuals are exposed to particulate matter and by which particulate matter is cleared from an exposed respiratory tract play the most significant roles in adverse health effects attributed to this class of air pollution. Without exposure there is no toxicity, and with exposure the body's natural clearance mechanisms play a key role in the ability of particulate matter to exert its toxic effects. The nature and composition of particulate matter is inherently complex, and therefore very difficult to characterize in terms of its toxicity. Topics that demonstrate this complexity involve not only issues regarding size fractions but also the chemical composition of each of the size fractions. On a

toxicological level, issues regarding the potential individual and cumulative toxicity of the chemicals that constitute particulate matter are not well understood and are the subject of current research (Schlesinger, 1995).

Deposition of particles in the airways is affected by three factors: particle size, morphology and airway anatomical factors. Particle size fractions are defined by their aerodynamic diameter, which takes into account both density and the ability to penetrate airways. However, as particles pass into a moist, warm airway, the size and density of that particle may change as it takes on water with increasing relative humidity (Witschi and Last, 1996). Morphology plays a role in the deposition of particles as a particle's shape may dictate its ability to pass into the intricate passages of the airways. The needle-like morphology of particles like asbestos not only enhances deep penetration into the lower lungs, but also hampers the clearance of these particles, which accounts for the carcinogenic properties associated with asbestos (Witschi and Last, 1996). In addition to aerodynamic diameter, studies on human nasal passage particle deposition implicate flow rate (e.g. breathing rate), nostril length to width ratio, and minimal nasal cross section areas as major factors affecting deposition (Kesavanathan and Swift, 1998).

Deposition occurs via the following mechanisms: interception, impaction, sedimentation, diffusion and electrostatic precipitation (Miller et al., 1979; Witschi and Last, 1996). The relationship between the aerodynamic diameter of particles and the regions of the respiratory tract where they are deposited are shown in Figure 4 (Spengler and Wilson, 1996). In the average adult, most particles larger than 10 μm are deposited in the nose or nasopharynx and oropharygeal regions. This is the result

21

of scrubbing high velocity air by small hairs, as well as inertial impaction and capture in the moist, mucus coated dermal lining of these airways. Smaller particles pass through the nasal region and are deposited in the tracheobroncial and pulmonary regions. Sedimentation brings about deposition in the smaller bronchi and bronchioles, while diffusional deposition is important in the low airflow velocity regions such as the alveoli (Miller et al., 1979).
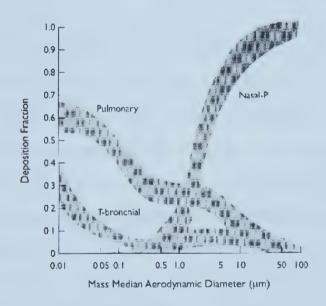

Figure 4. Particle Deposition in Various Regions of the Respiratory Tract According to Particle Size (adapted from Spengler and Wilson, 1997).

Particle clearance, the opposite of deposition, is an important process that is an aspect of a biological system's defense mechanism. Ultimately, clearance is a determinant of dosage as the dose retained is equal to the amount deposited subtracted from the amount cleared. Both unique as well as overlapping mechanisms exist in the clearance of particles, depending on the location in the airway (Witschi and Last, 1996). Clearance in the nasopharyngeal region is dependent upon the site

22

of deposition and the particle's solubility in mucus. Anterior clearance occurs via the mechanical process of blowing and wiping of dry, squamous epithelium and particle-laden mucus. Mucus located in the posterior of this region is propelled towards the glottis, where it is subsequently swallowed or expectorated. Generally, insoluble particles are likely to be cleared within a 1 to 2 hour time period, whereas soluble particles may diffuse across the epithelium and enter the lymph or bloodstream (Witschi and Last, 1996).

Clearance of the tracheobroncial tree is accomplished mainly by the upward movement of hairs that line the mucus-coated region. These beating cilia form the "mucocilliary escalator," which propel particles and other substances upward to the oropharynx. Clearance in healthy individuals is usually accomplished within 24-48 hours. The lower pulmonary region is cleared via several mechanisms, one of which propels macrophage-trapped particles upward to the mucociliary escalator following the same pathway as the clearance of the tracheobroncial tree. It is important to emphasize that there is very low air velocity in this region, thus allowing particles a longer residence time. Hsieh and Yu (1998) provide evidence that the clearance of particles with an extremely small dissolution rate occurs via two major mechanical processes: alveolar macrophage phagocytosis and migration, and the translocation of particles to the lymph nodes by penetrating the pulmonary interstitium. Therefore alveolar macrophages in this region play a major role in clearing small particles. These leukocytes phagocytize particles and ultimately enter the lymph. This may result in the initiation of an immune response. Otherwise, these particle-laden macrophages are cleared in the lymphatics. When penetration of the interstitium

does not occur, particles may be trapped in this region for very long periods of time resulting in a variety of potential toxic endpoints.

Once particles have been introduced into an airway, the above process of deposition and clearance play key roles in determining the time and amount of foreign matter retained. This is known as retention (Oberdorster, 1993) and is defined in the following manner:

Retention = Deposition − Clearance

The retention of potentially toxic particulate matter plays a key role in the exposure-dose-response relationship:

Response = f {Exposure/Dose, Toxicity}

In order for a compound to be considered toxic it must fit into this relationship. Should any of the links be missing, there will be no end-point toxicity.

It is important to note that since particulate matter is often composed of a complex mixture of organic and inorganic chemicals, it is exceedingly difficult to characterize on a toxicological basis. Furthermore, particulate matter is like a fingerprint in that no two particles are exactly alike in physical and chemical characteristics. While there have been many animal studies performed to assess the toxicity of particulate matter and some of its components, there is much work to be done in order to determine if toxicological evidence for health effects from inhalable particulate pollution can be extrapolated to humans. As pointed out by Schlesinger (1995), "while toxicological evidence clearly indicates the ability of certain ambient particles to induce increased morbidity…the responsible chemical species have not been definitely delineated."

Acute toxic responses to particulate matter are not as well understood nor are they as common as chronic toxic responses. The first point of contact for particulate matter is the smooth muscles located in the larger airways. Airway reactivity may occur via a process that causes these smooth muscles to contract. Any type of particulate that acts as an irritant may cause these types of muscle contractions. Similarly, particulates that initiate an immune response and trigger an asthmatic reaction rely on the contraction of smooth muscle to constrict airways (Witschi and Last, 1996).

Another common toxicologic response to particulate matter is allergic asthma, as implicated by recent studies (Vedal, 1997). This is a condition that is characterized as both acute and chronic in its clinical symptoms. An individual must first be sensitized to a particle that is recognized by the immune system as an antigen. In highly sensitive individuals, while allergic asthma is initially driven by a response to a specific allergen, the subsequent chronic inflammation appears to be perpetuated even in the absence of further exposure to allergen. Once such a status is reached, the airways of these individuals characteristically show hyper-responsiveness to environmental chemical irritants such as cigarette smoke and sulphur dioxide. The acute-type asthma occurs within seconds and is triggered by allergen-induced activation of sub-mucosal mast cells, resulting in fluid and mucus secretion and bronchial constriction.

Toxic pulmonary edema may result from lung injury due to exposure to particulates. This condition is related to allergic asthma in that it often involves the activation and recruitment of inflammatory cells from the immune system.

According to Witschi and Last (1996), the acute, exudative phase produces an increase in the alveolar-capillary barrier thickness. The edema fluid then alters ventilation-perfusion relationships within the lungs, thus limiting diffusive transfer. Ultimately, inflammatory cells are recruited from the airways in response to cytokines and inflammatory mediators. These inflammatory cells cause further damage by producing cytokines and, in turn, causing chronic inflammation which may result in irreversible damage to the airways.

Several additional chronic responses from exposure to particulate matter include fibrosis, emphysema, and lung cancer. Fibrosis results from repetitive lung injury which produces an overall increase in collagen fibers in the alveolar interstitium. Witschi and Last (1996) admit that the relationship between increased collagen deposition around small airways and lung mechanics is not well understood. Evidence currently exists which suggests that particles can cause fibrosis. Goldsmith et al. (1997) provide a great deal of evidence of an increase in occurrence of fibrosis in workers exposed to silica dust, and both the NIOSH (National Institute of Occupational Safety and Health) and the OSHA (Occupational Safety and Health Administration) have set standards for asbestos particles based on studies indicating increases in fibrosis and cancer among asbestos workers. Ultimately, fibrosis leads to a loss of lung function and lung capacity, resulting in respiratory distress.

Emphysema is the opposite of fibrosis in terms of the response of lungs to an assault. In this chronic disease, the lungs become over-compliant and increase in size, resulting in hyper-inflated lungs and a decrease in gas exchange. Witschi and Last (1996) suggest that particles can induce emphysema through a mechanism that

activates alveolar macrophages. Once activated, the macrophages release elastases that can break down lung elastin (a protein that promotes elasticity in healthy lungs) and cause emphysema.

In addition to acute and chronic lung injuries, lung cancer is a toxic endpoint that may result from exposure to particulate matter. As already mentioned, particulate matter may consist of a complex mixture of compounds in a single particle. Compounds comprising this particle may or may not be classified as carcinogens, for example, benzo-a-pyrene as a classified carcinogen and titanium dioxide as a classified non-carcinogen. Carlton (1994) points to animal studies that suggest that particulates need not be classified as carcinogens to produce lesions. In any event, many causes have been implicated in this chronic disease. Witschi and Last (1996) suggest that particulates have the potential to act as initiators, thus causing conditions that promote oxidative stress and potential DNA damage. Particulates may also act as promoters by increasing the rate of cell turnover, allowing for a greater chance of the manifestation of chemical carcingoenesis. In humans, lung cancers may have a latency period of 20 to 40 years, making the relationship to specific exposures difficult to establish.

Epidemiologists have performed numerous studies over the past decade focusing on the potential adverse health effects associated with air pollution and particulate matter. Particulate matter related adverse health effects observed in society include an increase in daily mortality (Schwartz and Dockery, 1992; Pope et al., 1992, 1995; Dockery et al., 1993; Schwartz et al., 1996), increase in respiratory symptoms and disease (Hoek and Brunekreef, 1993; Peters et al., 1997), increases in

respiratory hospitalizations (Pope, 1991; Thurston et al., 1992), and a decline in lung function (Pope and Dockery, 1992; Koening et al., 1993). Regardless of the mechanisms, many of the epidemiological studies show compelling evidence of associations between ambient particulate levels and human health. However, this is a controversial issue. In particular, when one reviews the body of work performed by epidemiologists in regards to potential adverse health effects, the following questions arise:

- does the study define and support a causal relationship (i.e. clear exposure and dose-response relationship);

- what inherent uncertainties are present in studies performed and how may they effect study outcomes;

- how is the issue of confounding (the presence of covariants in a study) addressed; and

- what are the implications of these studies?

In order for links between particulate matter and adverse human health effects to be definitively shown, there exist several areas of uncertainty which will require additional research (Phalen, 1998). First, while the epidemiological associations that relate particulate matter exposures to adverse public health aspects have been verified, the exact causes of morbidity and mortality remain largely unknown. Second, it remains unclear as to how health-compromised individuals might differ in their exposures and responses from healthy individuals. Third, lack of good individual dose assessments continues to weaken most studies. Finally, the

question as to medical or biological plausibility remains largely unanswered. It is likely that only future studies and research that focuses on these issues will add to our understanding and resolution of these questions.

2.2.3 Environmental Effects

The environmental effects of particulate matter range from inducing damage to vegetation (both agricultural and forest species) to the alteration of the global climate. The primary effects of particulate matter on vegetation are reduced growth and productivity due to interference with photosynthesis and phytotoxic impacts as a consequence of particle composition (WGAQOG, 1998). The mechanisms of action are thought to occur through the smothering of the leaf and/or indirect effects though the soil. Particles cover leaves and plug stomata, thereby both reducing the absorption of carbon dioxide from the atmosphere and the intensity of sunlight reaching the interior of the leaf, and suppressing growth of some plants (Elsom, 1992). Particle accumulation on the leaf surface may also increase the plant's susceptibility to disease. Particulate matter composition may also be relevant, causing both direct chemical effects on the plant and indirect effects through impacts on the soil environment. Plants subjected to deposition of particulate matter may be damaged, especially in the cases where other pollutants have attached to the particulate matter. Gas exchange can be disturbed, thus stunting growth in vegetation. Heavy metals and other toxic substances can infiltrate the soil, which may also lead to reduced plant growth and yield.

Suspended particulate matter in the atmosphere can also affect the earth's energy budget and thus exert an impact on climate by increasing the reflection of solar radiation from cloud-free portions of the atmosphere and by increasing the brightness and stability of clouds (U.S. EPA, 1996). Both mechanisms modify the earth's radiation balance so as to cool the earth's surface. It has been estimated that, on a global averaged basis, radiative cooling due to anthropogenic particles may substantially offset the radiative heating due to increases in atmospheric concentration of greenhouse gases such as carbon dioxide, methane and chlorofluorocarbons (Hinds, 1999).

2.2.4   Public Welfare Effects

Particulate matter can impact public welfare in a number of ways. One of the most obvious and significant effects is the reduction in atmospheric visibility caused by the absorption and scattering of light. The presence of a large amount of particles in the atmosphere can reduce the distance at which we can see the colour, clarity and contrast of far away objects (WGAQOG, 1998). The public may regard visibility as an indicator of overall air quality. Hence, reduced visual range is perceived to be a symptom of poor air quality, and consequently, quality of life in general may be negatively impacted. The visibility effects of particulate matter are dependent upon not just the concentration of particles in the atmosphere, but also particle size, particle chemistry and relative humidity. Fine particles in the air (i.e. $PM_{2.5}$) are the major cause of reduced atmospheric visibility because their average diameter is relatively close to the wavelength of sunlight (0.5 μm). Since fine particles are

primarily of anthropogenic origin, reduced visibility is primarily an anthropogenic impact. Significant scientific evidence exists showing that reducing anthropogenic emissions of fine particulate matter will improve visibility (U.S. EPA, 1996). The chemistry of the particles can also influence their ability to scatter light. Sulphates and nitrates, two major components of $PM_{2.5}$, are very effective at scattering light and play a large role in reducing visibility. Relative humidity can have a large impact on visibility because when relative humidity levels reach and exceed 70%, light scattering efficiencies of the particles begin to increase because particles swell in size due to increased water uptake by the particle (Elsom, 1992).

Aside from visibility impairment, there are other public welfare effects of particulate matter. The effects of particulate matter on material have been investigated in a limited way for metals, wood, stone, painted surfaces, electronics and fabrics (U.S. EPA, 1996). The deposition of particulate matter on materials can reduce their aesthetic appeal as well as increase their physical and chemical degradation. The most important degradation effects of particulate matter on materials are on the rates of corrosion and erosion, and soiling and discolouration. Particles may act as catalysts for the conversion of SO_2 and NO_X to sulphuric acid and nitric acid which accelerates the chemical degradation of susceptible material surfaces on which they are deposited (WGAQOG, 1998). In addition to contributing to the physical and chemical degradation of materials, particles can accumulate on cars, homes and laundry, all resulting in a nuisance impact. This can add to cleaning and replacement costs by reducing the life of the materials and finishes.

2.2.5   Particulate Matter Standards

To protect human health, the environment and public welfare the concentrations of allowable particulate matter are currently regulated in many jurisdictions. The variation in particulate matter standards across jurisdictions may reflect a number of factors. These include differences in the interpretation of human and animal data, differences in judgments based on societal, political or practical impact of the standard, differences in monitoring techniques, and differences in time periods when guidelines were developed.

Particulate matter is usually divided into three different size classes for regulatory purposes: TSP, PM_{10} and $PM_{2.5}$. TSP or total suspended particulate is generally any particle that is ≤ 40 µm in aerodynamic diameter and is usually regulated to reduce nuisance effects. The regulatory agencies tend to focus more on PM_{10} or particles that have an aerodynamic diameter of ≤ 10 µm as particles in this size range are considered inhalable. The third size range is defined as $PM_{2.5}$ or particles with an aerodynamic diameter of ≤ 2.5 µm. This size range has recently garnered much attention from regulators as it is considered inherently hazardous to human health. Many countries, regions, and regulatory agencies have different standards and guidelines for each combination of duration and specific size range. A brief summary of some of the current standards for particulate matter is presented in Table 2.

Table 2. Selected Current Particulate Matter Regulations and Guidelines.

Source	Regulation
Alberta Ambient Air Quality Guidelines (Alberta Environment, 1998)	TSP • 100 μg/m³ as a 24-hour average. • 60 μg/m³ as an annual geometric mean. Dustfall • 53 mg/100 cm² per 30 days in residential and recreation areas. • 158 mg/100 cm² per 30 days in commercial and industrial areas.
Occupational Health and Safety Act (Alberta Statutes and Regulations, 1997)	Total Mass • 5 mg/m³ of diatomaceous earth (based on an 8-hour occupational exposure limit). • 10 mg/m³ of nuisance particulate (based on an 8-hour occupational exposure limit). Respirable Mass • 2 mg/m³ of diatomaceous earth (based on an 8-hour occupational exposure limit). • 5 mg/m³ of nuisance particulate (based on an 8-hour occupational exposure limit).
Canadian National Ambient Air Quality Objectives (Cheng et al., 1998)	TSP • 120 μg/m³ as a 24-hour average. • 70 μg/m³ as an annual geometric mean.
Canada-Wide Standard (CCME, 2000)	$PM_{2.5}$ • 30 μg/m³ as a 24-hour average (to be achieved by 2010).
United States Environmental Protection Agency (U.S. EPA, 1997)	PM_{10} • 50 μg/m³ as an annual mean (based on the 3 year average of the annual arithmetic mean PM_{10} concentration). • 150 μg/m³ as a 24-hour average (based on the 3 year average of the 99th percentile of 24-hour PM_{10} concentrations). $PM_{2.5}$ • 15 μg/m³ as a 24-hour average (based on the 3 year average of the annual arithmetic mean $PM_{2.5}$ concentration). • 65 μg/m³ as a 24-hour average (based on the 3 year average of the 98th percentile of 24-hour $PM_{2.5}$ concentrations).
World Health Organization (Pryor and Barthelmie, 1996)	PM_{10} • 70 μg/m³ as a 24-hour average.
California, USA (Pryor and Barthelmie, 1996)	PM_{10} • 50 μg/m³ as a 24-hour geometric mean.

2.3   Receptor Models

2.3.1   Introduction

The purpose of many early studies of airborne aerosols was to determine the composition, size and shape of the particulate matter in a given airshed (Lee et al., 1971; Rahn, 1971, 1976; Lee et al., 1972; Lee and Goransen, 1972; Gladney et al., 1974; Paciga, 1975). More recently, the focus has shifted towards undertaking studies designed to compare local particulate matter levels with generally accepted standards. When these standards are exceeded, or when the standards are lowered, reductions are needed in the ambient concentrations of particulate matter. In order to achieve this goal, it is important to be able to identify the sources of emissions and to subsequently quantify their impact on an area of interest. This is essential because pollution controls impose both direct and indirect costs on industry and society and therefore must be applied in a practical and justifiable manner to achieve the greatest effect with the least social and economic disruption. For a reduction in smog in industrial London, reducing domestic coal combustion was an obvious step which had been under consideration since 1661 (Stern, 1976), but in many contemporary situations obvious solutions are no longer sufficient to meet the more rigorous standards of today.

Both qualitative and quantitative identification of source impacts can be accomplished through the use of models of which there are two basic types: source-oriented models and receptor models. The calculation of emission inventories is the simplest of the source-oriented models but this method can be confounded by

imprecise source estimation, particle deposition, secondary aerosol formation, or by low levels of emission (levels at which the uncertainties of measurement match or exceed the contribution to the ambient aerosols) (Friedlander, 1981). The temporal and/or spatial solution of atmospheric distribution functions, an approach known as dispersion modeling, can avoid many of these problems but raise a number of others. Due to the need for detailed meteorological data (some of which is not always available), accurate source inventories and an understanding of atmospheric dynamics, dispersion models are often considered to be approximate at best (Budiansky, 1980). Moreover, source-oriented models cannot easily nor accurately account for non-ducted emissions such as soil dust or fugitive industrial emissions. It is becoming more evident that source-oriented methods of emission modeling are useful for predicting the impact of a single new and well-characterized source but not for identifying and quantifying the numerous ambient particulate matter sources already existing in a complex environment.

The alternative approach to quantifying the impact of individual source types upon ambient particulate matter concentrations is called receptor modeling. Receptor models predict source contributions from the analysis of a set of representative ambient particulate matter samples taken at a given site or receptor (defined by Friedlander (1981) as a measurement point not directly located in the effluent stream of an emission source), rather than the converse as in dispersion modeling. They are thus independent of source emission data and are particularly useful for the source apportionment of aerosols that generally have many fugitive and distributed sources. Detailed reviews of receptor modeling methods and their

35

application to source apportionment in urban and rural atmospheres have been presented by several authors (Cooper and Watson, 1980; Gordon, 1980, 1988; Kleinman et al., 1980; Macias and Hopke, 1981; Watson et al., 1981; Dattner and Hopke, 1982; Stevens et al., 1982; Henry et al., 1984; Watson, 1984; Hopke, 1985; Watson, 1988).

Receptor models have important applications in air quality management. First, they may be used to approximate the impact of an individual source; this information can then be used to determine the need for controls or to assist in site selection. Second, they may be used to identify sources or categories of sources that contribute appreciably to ambient concentrations; regional strategies for air quality control can then be based on this information. Third, they may be used to estimate regional and national changes in the exposures of populations to particulate matter that would result from possible changes in energy development, conversion technologies and control measures (NRC, 1980).

When sampling and analyzing ambient particulate matter, properties measured might include: chemical composition, particle size, particle morphology or total mass. Although most of these features can be used to identify source types, the only measured parameter that can be used in receptor models to determine quantitatively a source's contribution to particulate matter levels is the concentration of different chemical species. Differences in this property among emission sources provide source fingerprints or tracers that can be detected by analysis of ambient samples.

The underlying assumption of all receptor models is that the measured concentration of a particular chemical species is the result of a linear sum of independent contributions by each source, natural or anthropogenic, that produces the particular measured chemical species (Henry et al., 1984). If a number of sources, p, exists, the total airborne particulate matter mass concentration measured at the receptor, m_j, will be a linear sum of the contributions of the individual sources, f_{kj}.

$$m_j = \sum_{k=1}^{p} f_{kj} \qquad \text{Equation (1)}$$

Since particulate matter from a given source generally contains more than one species, the airborne concentration is the product of two cofactors: the concentration of the species in the particulate matter emitted by the source and the total mass loading contributed by the source to the particular air parcel sampled. For a number of species, the fundamental mass balance can then be summarized by:

$$x_{ij} = \sum_{k=1}^{p} a_{ik} f_{kj} \qquad \text{Equation (2)}$$

where x_{ij} is the volumetric concentration of the ith species identified in the jth sample, a_{ik} is the mass concentration of the ith species in material from the kth source, and f_{kj} is the volumetric mass contribution of the kth source to the jth sample. Thus, receptor models try to express the measured ambient concentration in this finite linear expansion in the source profile vectors a_k (Hopke, 1988).

Although similarities in the different approaches to solving the fundamental mass balance are greater than their differences, they have historically been grouped into two categories: chemical mass balance models and multivariate techniques.

Chemical mass balance models use measured source signatures and ambient samples to solve for the source strengths by least-squares regression. Multivariate techniques derive both the strengths and compositions of sources from ambient samples and attempt to define the most probable linear combination of sources to explain the temporal variability in ambient chemical patterns. Each receptor modeling or source apportionment tool has its unique strengths and limitations, and each can provide valuable insight into sources contributing to particulate matter levels. The most cost effective tool or set of tools, however, will depend on the nature of the airshed, potential sources, and the accuracy and precision of source apportionment required.

2.3.2   Chemical Mass Balance Models

What is now known as the chemical mass balance receptor model (CMB) was first officially proposed by Winchester and Nifong (1971) and Miller et al. (1972). The basic premise of this method is that after an initial study of the airshed, in which the sources of particulate matter to be sampled are identified and their characteristic properties are individually determined, one can identify their contributions by measuring concentrations of many species in samples collected at a receptor site. The accuracy of the CMB model depends on the correct selection of the number and nature of sources in the study region. Thus, the most important step in the use of the CMB model is the development of the inventory of sources and the determination of the composition of the particulate matter emitted by a variety of air pollution sources. To achieve this, one must measure or obtain from the literature the

concentration profiles for each important source in the area and measure concentrations of the same species in ambient particles.

The CMB model consists of a least squares solution for a set of linear equations which express each receptor concentration of a chemical species as a linear combination of the composition of the particulate matter originating from various sources. In theory, accurate knowledge of the composition of the ambient particulate matter and of the emissions of every important source permits solution of a set of simultaneous equations for the contributions of each source to the particulate matter. In practice, the information is never as complete or reliable as desired, so a number of basic simplifying assumptions must be made when applying the CMB model (Pace and Watson, 1987):

1. Constant composition of source emissions over the period of ambient and source sampling.

2. Chemical species do not react with each other (i.e. they add linearly).

3. All sources with a potential for significantly contributing to the concentrations at the receptor have been identified and have their emissions characterized.

4. The source compositions are independent of each other.

5. The number of sources or source categories is less than or equal to the number of chemical species.

6. Measurement uncertainties are random, uncorrelated and normally distributed.

Pace and Watson (1987) point out that violating any of the above assumptions can have negative impacts on the interpretation of the results. Therefore, the CMB model must be applied in a manner that is very careful to combine the results with expert judgment and to validate them according to published guidelines. If applied in this way, the CMB model can be a very useful tool for determining the impact of various sources on particulate matter concentrations in an airshed.

As with most things, the CMB model is not without certain strengths and weaknesses as shown in Table 3 (Freeman et al., 1988). The strengths of the CMB model come from the fact that it has been used for almost 20 years and a large pool of results from many studies support its utility. In addition, it is unique in that it incorporates the uncertainty in both the ambient data and the emission source data. The CMB model, however, also has a major drawback in that it requires a prior knowledge of both the number and composition of the suspected source emissions. Another problem is that no account can be taken of secondary components or of chemical transformations occurring between the source and receptor.

In the first applications of the CMB method (Miller et al., 1972; Friedlander, 1973), it was necessary to assume the number and type of contributing sources to produce a set of probable profiles. Most likely because of a lack of comprehensive analytical information on source emissions, only a few tracer elements from each assumed source were modeled. The marker elements were normally those that were strongly associated with specific sources; examples are lead for motor vehicles,

sodium for sea salt, and vanadium or nickel for combustion of residual oil. This resulted in the inherent assumption that each of the tracer elements was unique to the corresponding source. Furthermore, some of the source composition data was based on feed materials, emission inventories or trapped pollutants rather than suspended particulate matter releases from the source of interest.

Table 3. Strengths and Weaknesses of the Chemical Mass Balance (Freeman et al., 1988).

Strengths	Weaknesses
Quantifies contributions of source types to PM_{10}.	Requires detailed and accurate source composition data that is not always available.
Does not require emission rates or detailed dispersion parameters.	Source compositions as perceived at the receptor may differ from those measured at the sources.
Incorporates effective variance weighing and error propagation to estimate confidence intervals of source contributions.	Cannot distinguish among individual sources with similar chemical compositions.
Uses singular value decomposition to identify excessive collinearity and uncertainty.	Not very reliable in areas with many diverse sources (i.e. urban airsheds).

Gatz (1975), although still using this iterative mass balance tracer calculation method, recognized the difficulty in finding unique tracers, either due to incomplete data or because more than one source had appreciable amounts of a single tracer element. Thus, both iron and manganese were used to represent iron and steel industry emissions, lead and bromine to represent automobile exhaust, and several

different solutions were computed using varying amounts of the tracer aluminum arising either from coal combustion or from wind-entrained soil. Although concentrations of the tracer elements mentioned above (and a few other elements) agreed with observed values to within a factor of two, there were some elemental concentrations which were calculated to be one to three orders of magnitude different from the measured value. Incorrect profiles, sources with similar tracers and incorrect assumptions regarding the number and type of contributing sources were all difficulties encountered at this stage.

It became increasingly clear that more comprehensive profiles were needed and for more sources. Between 1974 and 1979 a number of studies were conducted to determine the aerosol emission profiles of numerous sources including coal-fired power plants (Gladney, 1974), oil-fired power plants (Mroz, 1976), motor vehicles (Ondov et al., 1982), incinerators (Greenberg et al., 1978a, 1978b) and other industrial sources (Small, 1979). Due to these early works, extensive databases and compilations now exist in Watson (1979), Cass and McRae (1981), Hopke (1985), Chow and Watson (1988) and U.S. Environmental Protection Agency (1993). The use of these more comprehensive profiles with linear least square fitting has allowed decreased reliance on individual tracers and an increase in the number of available sources. The improvements in the quality of the source profile determinations have produced much better agreement between the calculated and measured elemental concentrations for airborne particulate matter in Washington, D.C. (Kowalczyk et al., 1978; Kowalczyk et al., 1982), Chicago, Illinois (Scheff et al., 1984) and St. Louis, Missouri (Dzubay, 1980), among others.

The study of Washington D.C. by Kowalczyk et al. (1978) focused on the concentrations of twenty-seven elements in ten samples from four widely separated sites. The contributions of coal and oil combustion, refuse incineration, marine aerosol, soil dust and mobile sources were determined using eight tracer elements in a least squares fit similar to that used earlier by Friedlander (1973). By employing this technique more than 90% of the marker elements were apportioned to the correct sources. A greater reliance on profiles obtained from actual stack measurements, a lack of diverse heavy industry in the Washington D.C. area and the inclusion of refuse incineration as a source were credited for the improved model.

Later, Kowalczyk et al. (1982) improved on their earlier study by using a set of one hundred and thirty samples from ten sites in Washington D.C. to perform a more detailed CMB for thirty-nine elements. It was assumed that the total composition of particulate matter could be represented as the sum of contributions from the same seven sources used in the earlier study plus limestone. Nine marker elements were used to characterize these sources: sodium for sea salt, vanadium for residual oil, lead for motor vehicles, zinc for refuse incineration, calcium for limestone, aluminum and iron for the sum of coal and soil, manganese for soil, and arsenic for coal. This detailed study allowed much more of the overall particulate matter mass to be accounted for by the assumed sources than the previous study.

The scope of the CMB method was further expanded in an extensive study of the Portland, Oregon particulate matter (Watson, 1979; Core et al., 1981). The study measured concentrations of about twenty-seven elements and species in two size fractions of particles from about thirty major sources in the Portland area.

43

Combining their results with data from the literature, they developed components for about fifteen different types of sources. The group collected ambient particulate matter in two size fractions at six sites in the Portland area and analyzed them for the same species as the source samples. They performed separate CMBs for the fine and coarse size fractions for each sampling period. By including a larger number of source components, very good agreement was achieved for the twenty-seven elements and chemical species that had been measured.

The CMB technique is currently recommended by the Environmental Protection Agency in the U.S. for source apportionment under the PM_{10} standard (Pace and Watson, 1987) and has been used for studies in Canada and Alberta (EAG, 1984; Lowenthal et al., 1997; Cheng et al., 1998). It has also been widely applied successfully in studies around the globe (Glover et al, 1991; Sharma and Patil, 1994; Chow et al., 1996; Alonso et al., 1997; Chen et al., 1997). More detailed listings of the various applications of the chemical mass balance can be found elsewhere (Cooper and Watson, 1980; Hopke, 1985; Gordon, 1988; ARC, 1998).

2.3.3   Multivariate Techniques

An alternative approach to receptor modeling which has been successful in identifying source contributions in urban areas and in other areas where the sources are not known with complete certainty is to use multivariate techniques. Multivariate techniques are statistical methods that provide information on contributing sources through an analysis of the variability in measured particulate matter properties within a large data set. This approach is predicated on the assumption that chemical

components released from a single source will have a common temporal variability at the receptor and, furthermore, that these co-varying species can be related to the composition of a source within the airshed.

The principle advantage of using multivariate techniques over the CMB model is that no prior assumptions need be made about either the number or composition of sources (Gordon, 1980; Freeman et al., 1988). Thus, secondary particles that become associated with primary particles between their release and collection can be incorporated in the analysis. Another advantage, as described in Table 4, is that data sets used in multivariate techniques can include not only particle concentrations, but also particle size group, meteorological data, concentrations of gaseous pollutants measured simultaneously with sample collections, measure of visibility and so forth. Although this feature has not been exploited in particulate matter studies, Thurston and Spengler (1985a) used many metrological variables in addition to elemental concentration in their interpretation of sources of inhalable particulate matter in Boston, Massachusetts.

Multivariate techniques also have weaknesses as demonstrated in Table 4 (Gordon, 1980; Freeman et al., 1988). Because they are based on variations rather than absolute concentrations, they work best with data in which there are large variations from sample to sample. They are not effective for data for which there is little variation. Another weakness is that they cannot currently resolve components that have very similar compositions (e.g. coal emissions and soil). In its usual form, multivariate techniques suffer from another problem: the relative contributions of sources within the factors cannot be obtained. The output indicates only that part of

the variation of the concentrations that is explained by the sum of the sources in each factor. A further disadvantage of multivariate techniques is that large numbers of ambient air samples must be collected and analyzed, and statistically independent source tracers must exist for each source category.

Table 4. Strengths and Weaknesses of Multivariate Techniques (Gordon, 1980; Freeman et al., 1988).

Strengths	Weaknesses
Handles correlated variables.	Components rarely account for total variance.
Simplifies large, correlated data sets to small, uncorrelated factors.	Not effective if data set has small variability in space and time.
Can use chemical and meteorological data simultaneously.	Cannot distinguish between components that are highly correlated with each other.
Identifies contributing source types, chemical character and direction with respect to receptors.	Requires a large data set.
Dependent variables can be linearly regressed on principle components.	Lacks necessary physical constraints to determine source compositions and source contributions.

The many types of multivariate techniques that have been employed in previous studies have some fundamental differences that must be reviewed. In truly multivariate systems the common pairwise correlation coefficient, used in earlier particulate matter composition studies, has limited meaning and two correlated

46

elements may only be associated because of a third as yet unknown variable. Hierarchical cluster analysis has also been utilized (Gaarenstroom et al., 1977). In this technique each element is considered as a separate cluster and these are joined one at a time into progressively larger clusters that presumably resemble common sources of variance. However, this technique does not allow observation of multiple source relationships for single variables and only assists in the observation of highly intercorrelated clusters.

In factor analysis, a much more sophisticated method of statistical analysis, the variability in the data set is assumed to be due to an unknown number of underlying causal factors, in a fashion similar to the CMB model where elemental concentration is a linearly additive sum of underlying source contributions. These underlying causalities must then be interpreted in terms of their contributions to the variance of the data set. Relationships between each of the variables (elements) and the underlying causalities (factors) are defined by the degree of correlation between them. The amount of variance for a particular variable that is not accounted for by these correlations is apportioned to the unique variance according to:

$$\overset{\longleftarrow \text{true variance} \longrightarrow}{\text{Variance} = \text{common factor variance} + \underset{\longleftarrow \text{unique variance} \longrightarrow}{\text{specific variance} + \text{error.}}} \qquad \text{Equation (3)}$$

In this classical factor analysis model the variance is apportioned between the common factor variance and the unique variance, whereas in principle component analysis there is no unique variance and the total variance is apportioned among the common factors. In either case, elements which are strongly affected by (correlated to) a particular factor would then provide a qualitative chemical identification of that

47

factor which could be subsequently associated with a particulate matter source within the airshed. The proportion of the variance of a particular variable that has been attributed to the common factors, the communality, can then be calculated and, by difference, the remainder represents the unique variance. Variables (elements) with large unique variance are indicative of a source of variance unrelated to the common factors, such as measurement or sampling errors. Factor analysis in general has been treated in more detail by Harman (1976), and Heidam (1982) has discussed the use of factor analysis exclusively for source identification in particulate matter studies.

Probably the first use of multivariate analysis for particulate matter source identification was a study of ambient particulate matter data from the National Air Sampling Network by Blifford and Meeker (1967) using principle component analysis. Hopke et al. (1976) later performed factor analysis on concentration data for eighteen elements in ninety particulate matter samples from the Boston area and identified six common factors: crustal dust/flyash, marine aerosol, residual oil combustion, bromine related from fresh automotive exhaust, refuse incineration and an unidentified source. These sources accounted for almost 99% of the variance in the data set. It was concluded that more elements, such as lead and arsenic, should be included in the analysis for better source identification. Gaarenstroom et al. (1977) used factor analysis in their study of airborne particulate matter in Tucson, Arizona in which six factors were isolated, including: soil, a well-mixed long-distance aerosol from outside the city, combustion emissions, automotive emissions, an unknown source and a factor which represented the common variance imparted by

an analytical procedure. In this analysis chemical species such as NH_4^+, SO_4^{2-} and NO_3^- were included in addition to the pure elements.

Gatz (1978) applied a principle component analysis to particulate matter composition data for St. Louis, Missouri. Nearly four hundred filters collected at twelve sites were analyzed for up to twenty elements. The analysis resulted in the production of five common factors. No significant differences were reported between principle components and factor analysis or between the various rotation techniques tested. Several meteorological and miscellaneous variables (e.g. wind direction and speed, amount and duration of precipitation, and day of the week) were also included, but only wind direction provided any significant factor loadings and these were generally moderate. A comparison of various sites was used to distinguish between area sources (e.g. soil/flyash, automotive) and local sources (e.g. titanium pigment, secondary lead smelter). In this study, as in that performed by Hopke et al. (1976), the elemental similarity (collinearity) between crustal dust and coal flyash posed a problem for source identification. On the other hand, Gatz claims that a variation found in lead factor loadings between sampling sites, on automotive factors, was demonstration of the ability of factor analysis to identify the existence of two collinear sources of lead emission: automotive exhaust and a secondary lead smelter. Morandi et al. (1987) employed factor analysis and multiple linear regression to attempt to differentiate between multiple sources of lead (motor vehicles, airborne soil, industrial emissions, paint-related and zinc-related sources) and iron (soil resuspension, paint pigment and industrial emissions). This composite method permitted apportionment of the non-unique element where unique tracers

49

existed for all sources of that element except one. The method was of limited use where more than one source emitted the same tracer.

Since 1980 there has been an increasing effort to extract quantitative source contributions from multivariate analysis. Target Transformation Factor Analysis or TTFA (Alpert and Hopke, 1980), Absolute Principle Component Analysis or APCA (Thurston and Spengler, 1985b; Keeler et al., 1990a; Morandi et al., 1991) and Specific Rotation Factor Analysis or SRFA (Koutrakis and Spengler, 1987; Keeler et al., 1990b) are all techniques that attempt this. TTFA attempts to develop a set of test vectors, each of which duplicates the factor axes developed in the preliminary factor analysis. The resulting vectors are scaled by multiple regression of the sample weights and the calculated source contributions. In the other two techniques a regression of elemental concentration and mass on the factor scores is performed.

In each of these hybrid models the resulting source compositions tend to not only resemble a composite source rather that a unique one (Alpert and Hopke, 1980; Hopke, 1988; Javitz et al., 1988), but also tend to be approximate at best. Okamoto and Hayashi (1990) and Van Borm et al. (1990), also noting that factor analysis/multiple regression techniques of this type produce source profiles resembling multiple sources, suggested that this effect was caused by similar temporal variation in source contributions to the sampler as a result of common meteorology, that is, the variance due to meteorology was greater than that due to difference in source composition.

Much discussion has been generated by the use of these methods and of classic factor analysis (Hopke, 1985; Redman and Zinsmeister, 1982; Richman,

50

1985), and even the statistical validity of simple factor analysis when used as more than just a screening technique has not been established conclusively (Henry, 1987). More recently, Hopke (1988) has performed a sensitivity study and review of the TTFA method and concluded that unique apportionment solutions are not possible with this technique and that there are limitations in the ability of TTFA to both enumerate and identify profiles for contributing sources. Specifically, collinearity restricts the number of resolvable sources and results in the identification of linear combinations of non-orthogonal sources.

Thus, multivariate techniques such as factor analysis and principle component analysis are most helpful when used for screening data in order to identify unusual or major sources, for the source apportionment of particulate matter in areas with unknown sources, for qualitatively assessing source profile, and for assisting further modeling. Their major benefit is that they are able to incorporate the variability of ambient concentrations and source emissions in a way that the CMB model cannot at the present time. Multivariate techniques have recently been successfully employed in studies throughout the globe (Rojas et al., 1990; Fung and Wong, 1995; Harrison et al., 1996; Harrison et al., 1997; Bandhu et al., 2000), the United States (Morandi et al., 1990; Ehrman et al., 1992) and Canada (Biegalski et al., 1998), but their application in Alberta seems to have been relatively neglected to date. More detailed listings of the uses of the different multivariate techniques can be found elsewhere (Cooper and Watson, 1980; Dattner and Hopke, 1982; Hopke, 1985; Watson, 1988; Gordon, 1988; ARC, 1998).

2.3.4 Source Elemental Profiles

Regardless of whether chemical mass balance models or multivariate techniques are employed in receptor modeling, it is apparent that a thorough understanding of source elemental tracers and source elemental abundance profiles is required if the interpretation of the results is to be straightforward and accurate. Differences in the chemical composition of the particulate matter emitted from a particular type of source can be seen from country-to-country, region-to-region and sample-to-sample. However, generalizations can be made about the types and abundances of certain dominate species. In a general way, both natural and anthropogenic sources of particulate matter produce important emissions of distinctive elements to the atmosphere. The ability to recognize these distinctive elements during receptor modeling is an essential ingredient for an accurate apportionment of the particulate matter to sources. Table 5 illustrates common known sources of particulate matter and the important chemical tracers or signatures of each (Gordon, 1980,1988; Gordon et al., 1981; Stevens and Pace, 1983; EAG, 1984; Morales et al., 1990; Rojas et al., 1990; Huang et al., 1994; Biegalski et al., 1998; Marcazzan, 1998). Included in the table is an indication of the distinctive element tracers that are most often used to mark a source. As an aside, in Alberta, as with most of the developed world, the appearance of the main tracers of vehicle emissions (Pb and Br) has dropped considerably after the complete ban of leaded fuel in December 1990 (Cheng et al., 1998). Consequently, other marker elements such as Zn and Cd are typically used to identify automotive emissions.

Table 5. Important Source Elemental Tracers (Gordon, 1980,1988; Gordon et al., 1981; Stevens and Pace, 1983; EAG, 1984; Morales et al., 1990; Rojas et al., 1990; Huang et al., 1994; Biegalski et al., 1998; Marcazzan, 1998).

Source	Elemental Tracers (**bold** denotes a distinctive marker)
Crustal Material	**Mn**, Al, Si, Fe, K, Ca, Ti
Coal	**As**, **Pb**, Al, Si, Fe, K, Ca, Ti, I, Se
Oil	**V**, **Ni**, Mo, S
Refuse Incineration	**Zn**, **Cl**, Pb, Sb, Cd, K, Ag, In
Automotive	**Pb**, **Br**, **Zn**, Cd, Sb
Biomass Combustion	**Cl**, **K**, **Zn**, S
Regional Sulphates	**S**, Se, Pb, Cu
Salt	**Cl**, **Na**
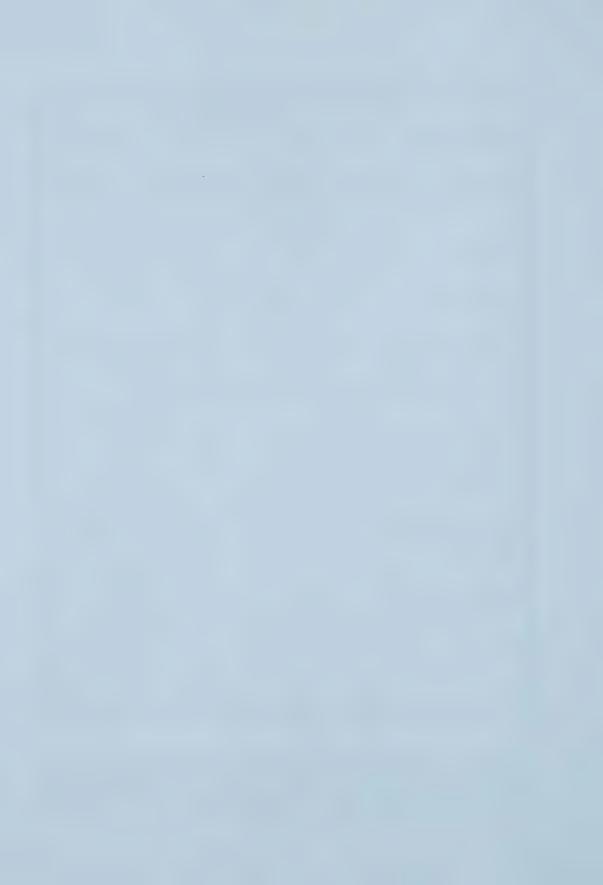
In addition to source elemental tracers, a detailed understanding of source elemental abundance profiles as determined from an analysis of a source sample is crucial. The CMB model requires this information as a model input and multivariate techniques rely on it to aid in source identification. Table 6 presents a detailed summary of source elemental abundance profiles for both the fine and coarse size fractions that have been determined from previous emission profile studies and previous receptor modeling studies. It must be noted that motor vehicle emissions include sources from the combustion of fossil fuels and tire and brake lining decay. Additionally, this emission source can vary with the individual driving mode (i.e. ideal, accelerating, decelerating, cruise) (Chow and Watson, 1998).

Table 6. Elemental Abundances Based on Source Contributions.

Particulate Matter Emission Source	Elemental Abundance	
	Fine Main (> 1%) and Trace (< 1%)	**Coarse** Main (> 1%) and Trace (< 1%)
Motor Vehicles[1, 2, 3, 4, 5, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20]	**S, Br, Pb, Ca, Fe, Zn, Na** Si, Cl, Al, P, Ca, Mn, Fe, Zn, Br, Pb, Cr, Ni, Sr, Ba, Ti, Cu	**Br, Fe, Sb, Na, Ca** S, Cl, Zn, Mn, Pb, Cd, Fe, Si, Al
Residual Oil[1, 3, 5, 6, 8, 9, 11, 16, 17, 18, 19, 20, 21]	**V, S, Ni** Zn, Fe, Si, Cl, Ti, Cr, Co, Se	**V, S, Ni, Na, Fe** Al, Si, Cl, K, Ti, Cr, Cu, Br, Al, Mn, Zn, Pb
Oil Fired Power Plants[8, 10, 17, 19, 20]	**S, Na, Ca, Pb** Al, Si, P, K, Zn, V, Ni, Se, As, Br, Ba	**V, Ni** La, Sm
Soil (undisturbed and agricultural)[1, 2, 3, 4, 5, 6, 7, 9, 10, 11, 16, 17, 18, 19, 20, 21, 22, 23]	**Si, Fe, Al, K, Ti** Pb, S, Ca, Fe, I	**Si, Al, Mg, K, Ca, Fe** Cr, Mn, Sr, Zn, Ba, P, S, Cl, Ti, Sb, Pb, Na, V, Cu
Refuse Incineration[1, 2, 8, 10, 11, 17, 18, 19, 20, 24]	**Cl, Si, S, Ca, Fe, Br, Pb** Al, Ti, Zn, Hg, V, Mn, Cu, Ag, Sn, K, La	**Zn, Na, Al, Ag, In** Br, Fe, Sb, Cu
Regional Sulphate[2, 3, 5, 6, 16, 17, 18, 19, 20, 23]	**S, Pb, Fe, Si** Zn, Al	**S, Al, Fe** K, Pb, Mn
Coal Fired Power Plant[1, 8, 11, 16, 17, 18, 19, 20, 24, 25]	**Si, Al, S, Ca, Fe** P, K, Ti, V, Ni, Zn, Sr, Ba, Pb, Cl, Cr, Mn, As, Se, Br, Rb, Zr	**Al, Fe, S, Si, Ca** Na, K, Ti, V, Mn, Cu, Zn, Pb
Road Dust (paved and unpaved)[1, 4, 8, 14, 16, 17, 18, 19, 20, 21, 26, 27, 28, 29]	**K, Ca, Fe, Si, Na, Cl** S, Cl, Pb, Zn	**Al, Fe, Si, K, Ca** Cr, Sr, Pb, Zr, P, Zn, Ba, S, Cl, Mn, Ti, Na, V, Mg, Co, Sb, Ce, La, Sm, Th, Hf, Sc, Ni, Cu, Br
Biomass Combustion[3, 4, 8, 17, 19, 20, 30, 31]	**Cl, K** S, Ca, Mn, Fe, Zn, Br, Rb, Pb	**Cl, K** As, Cd, Cr, Cu, S, Pb, Ca, Mn, Ni, Hg, Se, Zn, Fe
Construction[8, 9, 10, 16, 17, 19, 20]	**Si, Al, Fe, K, Ca** S, Al, Pb, K, Ti, Mn, V, S, Zn, Cl, Cu, Rb, Cr, Pb, Mg	**Si, Al, K, Ca, Fe** Cr, Mn, Zn, Sr, Ba, S, Ti, Mg, Na, V, Cu, Ni, Br
Marine[4, 6, 8, 10, 11, 17, 19, 20, 23, 24, 26]	**Na, Cl** Al, Si, K, Ca, Fe, Cu, Zn, Ba, La, Ti, V, Ni, Sr, Pb, Ag, Sn, Sb, Br	

[1]Alpert and Hopke, 1980; [2]Alpert and Hopke, 1981; [3]Rojas et al., 1990; [4]Morales et al., 1990; [5]Tuncel et al., 1985; [6]Pratsinis et al., 1988; [7]Stevens et al., 1984; [8]Chow, 1995; [9]Fung and Wong, 1995; [10]Huang et al., 1994; [11]Kowalczyk et al., 1982; [12]Silva and Prather, 1997; [13]Liu et al., 1995; [14]Kulmala et al., 1986; [15]Linton et al., 1980; [16]Cooper and Watson, 1980; [17]U.S. EPA, 1993; [18]Harrison et al., 1996; [19]Chow et al., 1992; [20]Hopke, 1985; [21]Cass and McRae, 1983; [22]Alberta Health, 1997; [23]Maenhaut and Cafmeyer, 1998; [24]Van Borm et al., 1990; [25]Davidson et al., 1974; [26]Swietlicki et al., 1996; [27]Janssen et al., 1997; [28]Fergusson and Ryan, 1984; [29]Hopke et al., 1980; [30]Sexton et al., 1985; [31]Stevens, 1985

2.4   Particulate Matter Studies in Alberta

In contrast to the large body of receptor modeling development and application literature originating in the United States and elsewhere, there has been remarkably little such work performed in Canada and even less in Alberta. Early characterization studies of urban airborne particulate in Alberta have been followed by more recent comprehensive studies involving both urban and rural areas. However, despite the increasing number of studies in the past ten years, very few have led to extensive receptor modeling research and application in Alberta and, until this study, none have involved a sampling and analytical program designed specifically for particulate matter characterization and receptor modeling in a regional background setting in Alberta.

In one early study of particulate matter source contributions in seven Canadian cities, including Edmonton, Alberta (EAG, 1984), a commercially available iterative CMB model was employed using dichotomous sampling data. Major sources in Edmonton including crustal material (dominated by road dust), vehicle emissions and regional sulphate were deemed to be modeled with confidence but locale-specific or minor sources were not (Figure 5). An even earlier study conducted by Alberta Environment (1982) represents one of the first investigative applications of chemical analysis to particulate matter research in Alberta. The results indicate that most (95%) of Edmonton's total suspended particulate (TSP) originates from lithophilic material; in particular, the elements silicon, aluminum, potassium, iron and

titanium which are essentially of crustal origin. Small amounts of trace elements such as zinc and nickel and other aerosols such as regional sulphates were also detected.

□ Road Dust 74.8%	▣ Transportation 9.4%
□ Others 12.5%	□ Steel 0.2%
■ Construction 1.8%	□ Secondary Sulphate 1.5%
▣ Incineration 0.7%	
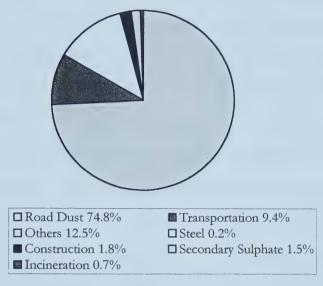
Figure 5. Distribution of PM$_{10}$ within the City of Edmonton (adapted from EAG, 1984).

A particularly comprehensive report by Alberta Environment (1996) details the characteristics of inhalable particulate matter in Edmonton and Calgary from 1984 to 1993. During the study period, mean PM$_{10}$ mass loadings were 26.3 and 29.1 $\mu g/m^3$ in Calgary and Edmonton respectively. For the same time period, a cross-Canada range of mean PM$_{10}$ concentrations from 18 to 46 $\mu g/m^3$ was reported, with most sites between 20 to 30 $\mu g/m^3$. Mean PM$_{2.5}$ mass loadings were 11.1 and 11.2 $\mu g/m^3$ in Calgary and Edmonton respectively. A cross-Canada range of mean PM$_{2.5}$ concentrations of 8 to 22 $\mu g/m^3$ was reported for the same time period. The reported chemical profiles for ambient particulate matter in Edmonton and Calgary

seem to be very similar, especially for fine particles. Of the elements analyzed, silicon made the largest contribution to the coarse mass loading while sulphur (i.e. sulphate) was the most significant element in the fine size range. A CMB model was employed to apportion the particulate matter to probable sources. Even though uncertainties were large because no local source profile data and regional background data were available, the main sources of coarse particulate matter in both cities were allocated to mineral soil and road dust and the main sources of fine particulate matter in both cities were allocated to transportation and wood burning (Cheng et al., 1998).

A more recent study reported on the characteristics of the particulate matter sampled in a small rural town in northern Alberta (High Level) which has known local industrial point sources of particulate matter, specifically a wood waste burner (McCullum and Kindzierski, 2000). Integrated samples collected over four seasons had an average 24-hour PM_{10} concentration of 20 $\mu g/m^3$ and an average 24-hour $PM_{2.5}$ concentration of 10 $\mu g/m^3$. From an elemental analysis using SEM-EDX, a total of 18 elements were detected including: Si, Ca, Fe, Al, K, Na, Mg, Cl and Rb in >1% relative abundance and Ti, Mn, P, S, Cu, V, Cr, Ce and Sr in <1% relative abundance. Based on receptor modeling employing principle component analysis, six main sources were shown to account for approximately 79% of the variance between the elemental concentrations measured. The six sources included crustal material (26%), road dust (13%), road salts (12%), vehicle emissions (11%), residual oil (10%) and regional sulphate (7%).

As stated earlier, there has been a general lack of studies concerning rural or regional background particulate matter conducted in Alberta, and for that matter, across Canada and the rest of the world. However, Cheng et al. (2000) have recently reported on the characteristics of particulate matter in numerous rural Alberta locations. Mean $PM_{2.5}$ and PM_{10} concentrations at remote rural Alberta locations were reported as 3.2 and 8.8 $\mu g/m^3$ respectively. The mean $PM_{2.5}$ and PM_{10} concentrations at rural Alberta locations within 100 km of regional industrial and urban sources (i.e. regional background locations) were 7.9 and 16.8 $\mu g/m^3$, respectively. While a limited chemical analysis was done on the particulate matter collected at these sites, it seems no receptor modeling was attempted to resolve the sources of the particulate matter in remote rural or regional background sites in Alberta.

It has been estimated that regional background concentrations of particulate matter are likely to dominate in Alberta and the prairies, where local anthropogenic sources are relatively few in number and small in emissions (Cheng et al., 1998). Regardless of this fact, very few studies have been conducted outside of major urban centers in Alberta whereby an estimate of regional background particulate matter characteristics could be determined (Sandhu, 1998). There does exist a large body of knowledge concerning the levels of particulate matter in urban and rural areas of Alberta and some limited receptor modeling studies have been conducted, however, none of these seem to have been designed solely for the purpose of resolving regional background sources.

CHAPTER 3: STUDY AREA

3.1   Selection Criteria

The goal of this study was to fill a gap in the current literature by establishing the characteristics and sources of regional background PM_{10} in Alberta. To achieve this goal, a community was required for which the characteristics and sources of the regional background particulate matter could be estimated. By definition, a regional background community must allow for the measurement and characterization of particulate matter from open and natural sources, and from the long-range transport of anthropogenic particles and precursor gases from urban centers and regional anthropogenic point source emissions (Munn, 1981).

To ensure that valid results were obtained, the regional background community selected for this project had to satisfy a number of criteria. Firstly, a fundamental requirement was that of a rural environment (i.e. a population of less than 6000). Other areas were avoided, as the results would most likely be influenced more by changes in a local urban or industrial environment than in a regional one. Secondly, the community could not have any significant local anthropogenic point source emissions of particulate matter whatsoever. The minimum distance of a regional site from the nearest pollution sources depends on the intensity of the pollution sources. For large sources such as coal-fired power plants the distance needs to be as much as 40 km (Munn, 1981). Thirdly, while all local anthropogenic point source emissions had to be omitted, a community that was under the influence

of the long-range transport of particles and precursor gases from an urban environment and regional anthropogenic point source emissions was required. Finally, topography and other factors necessitated local criteria to be set. The regional site needed to be located sufficiently far away from built-up areas so as not to be dominated by fluctuations in pollution from local sources. As for topography, valleys were to be avoided since, at least in temperate and cold climates such as Alberta, they collect cold and stable air at night and in the winter that is not representative of the region. Among other local factors that were considered, local dust was considered the most important, which emphasized the need to be a sufficient distance from roads and keep good grass cover on earth surfaces.

3.2   Description of Study Area

With these selection criteria in mind, the Town of Devon, Alberta was selected as the regional background community where this project was to be executed (Figure 6). Devon is a community located in the central area of Alberta at approximately 53°N latitude and 113°W longitude with an elevation of 700 m. The population of Devon as per the 1996 Canada Census is 4,496. It was originally built to accommodate the oil boom of 1947, after the discovery of the Leduc-Woodbend Oil Field by Imperial Oil. The name "Devon" comes from the Devonian rock formation base in which oil is found. Devon is a growing community whose main economic base is in oil, natural gas, agricultural products and tourism. It is bordered by Highway 60 to the west, the North Saskatchewan River to the north and east, and by Highway 19 to the south. Additionally, the community is surrounded in every

direction and for many kilometers by agricultural fields and open land. Devon is situated in the Aspen Parkland ecoregion of Alberta. This type of area is dominated by vegetative species such as aspen and rough-fescue grassland. The principal soil type in this region is dark brown or black chernozemic making it a prime area for agriculture.

By selecting Devon, the first criterion that was set was satisfied: a rural community with a population of approximately 4,500. The second criterion was also satisfied, as there are no significant anthropogenic point source emissions of particulate matter within the community or immediate surrounding areas. Of note, however, is the presence of an Imperial Oil Natural Gas Processing Plant located in Devon that has a flare stack which is ignited at random times with waste gas. This stack was not considered a significant anthropogenic point source of particulate matter, though, as it does not release particulate matter and is used very rarely (Bertrand, 2000). In addition to the flare stack, the Devon Research Centre, which primarily deals in heavy oil research, is located in the community and has a number of laboratories that vent various materials through the roof. This too was not considered a significant anthropogenic point source of particulate matter since most laboratories do not vent particulate matter in any form and any that do only do so in miniscule amounts (Bertrand, 2000).
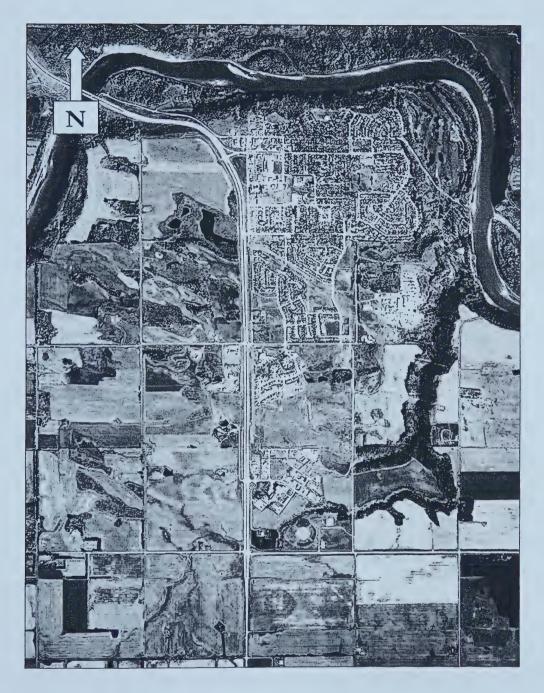
Figure 6. Aerial View of Devon, Alberta.

Devon's location (only 27 km southwest of the City of Edmonton and approximately 50 km east and southeast from numerous regional industrial point sources of particulate matter (i.e. coal-fired power plants)) satisfied the third criterion. The proximity to these regional sources ensured that the area was under the influence from the long-range transport of particles and precursor gases from an urban environment and regional anthropogenic point source emissions. Finally, the local topography of Devon is such that it is located sufficiently far away from built-up areas so as not to be dominated by fluctuations in pollution from local sources. The North Saskatchewan River Valley is located immediately to the north and east of Devon. To avoid potential problems with collecting samples not representative of the region, sampling was conducted outside of the valley. Additional factors that made Devon the best selection were it's sufficient distance from intensely traveled roads and highways and the good grass cover on earth surfaces throughout the entire community and neighboring areas.

3.3   Air Quality in the Study Area

3.3.1   Meteorology

Devon is located in the central belt of the northern cool temperate zone. The Rocky Mountains, immediately to the west, prevent any sustained influence of the Pacific Ocean and lead to a continental climate with long, cold winters and short, warm summers. Detailed data for specific meteorological conditions are not available for Devon; therefore, data for Edmonton (only 27 km to the northeast) are reported

in their place (Bowser et al., 1962). The mean winter temperature (November to March inclusive) is –8.7°C. The mean summer temperature (April to October inclusive) is 14.4°C. The average frost-free period is about 100 days with an extreme variation from about 50 to 150 days. The mean annual precipitation is 412 mm. June, July and August are the months of highest rainfall, totaling an average of just under 260 mm. Approximately 70% of the precipitation falls as rain and the remainder as snow, usually when the ground is frozen. The average annual snowfall is just over 1500 mm, varying from 300 to 2700 mm. Summer rains are generally of the low intensity variety. The probability of over 3 cm of rain falling in less than one hour is only one year out of five. The maximum precipitation in any one 24-hour period has not exceeded 150 mm. Wind velocity averages just less than 16 km/hr with little variation throughout the year. Prevailing upper level winds are west-northwesterly. There is an average of about 2,175 hours of sunshine per year. Daylight ranges from 7.5 hours in the winter to 17 hours in the summer.

3.3.2   Historic PM_{10} Data

As of the onset and subsequent completion of this study, there have been no other known studies of particulate matter conducted in or immediately around the community of Devon to report. There exists, of course, much data from Edmonton and surrounding communities and areas, but no comparisons can be made as each has different conditions and unique influences that would make any such comparison invalid. This lack of particulate matter data for the Devon area is another reason for the need of the present study.

3.3.3   Potential PM$_{10}$ Sources

Potential PM$_{10}$ sources in and around Devon include natural sources, local open and non-point sources, and the long-range transport of particles and precursor gases. The potential natural sources of PM$_{10}$ include: windblown soil and mineral particles, debris from wildfires, and biological material such as pollen, spores and bacteria. The potential local open and non-point sources include: agricultural activities, vehicle exhaust, construction activity, road dust, gravel road dust, prescribed agricultural burning and residential wood burning. The potential sources of particulate matter from the long-range transport of particles and precursor gases include: anthropogenic emissions from Edmonton, from nearby coal-fired power plants, and from other regional industrial activities such as fossil fuel combustion, natural gas compressor stations and flare stacks, gas processing plants and incinerators. In addition, the Edmonton International Airport is located 12.8 km to the east and, as a consequence, Devon experiences high air traffic overhead throughout the year.

CHAPTER 4: SAMPLING AND ANALYSIS METHODS

4.1   Study Description

The goals of this study were to establish the regional background level of PM_{10} in Alberta, characterize its chemical composition and morphology, and trace its origins using a receptor-based analysis method. To reach these goals, sampling and analysis methods were researched and developed for particulate matter sampling and monitoring, laboratory analysis, data analysis, and quality control and quality assessment. A representative location in the community of Devon, Alberta was judgmentally selected based on knowledge of siting requirements, potential sources and prevailing meteorological conditions. An air-sampling and monitoring program was developed which involved two 22-day sampling periods spread over two seasons to account for seasonal, meteorological and human activity variability. A Tapered Element Oscillating Microbalance (TEOM) was used to continuously measure PM_{10} levels, and an Airmetrics Minivolume Portable Survey Sampler (MiniVol) was used to collect 24-hour PM_{10} filter samples. Laboratory work involved Scanning Electron Microscopy with Energy Dispersive X-Ray (SEM-EDX) analysis to establish the elemental composition and morphology of the PM_{10} samples. From the measurements obtained, a receptor model utilizing principle component analysis (PCA) was performed to determine the most likely sources of particulate matter. Quality control and quality assessment plans were developed and strictly followed.

4.2   Particulate Matter Sampling

4.2.1   Methods

There are a large number of sampling systems available for PM_{10} each with its own advantages and disadvantages. Some of these systems are integrated sampling instruments such as high-volume PM_{10} samplers and low-volume dichotomous samplers that require gravimetric analysis to determine particulate matter concentrations. Some are direct-reading samplers including instruments such as light scattering devices, quartz crystal microbalances and beta-attenuation monitors that do not require gravimetric analysis. This report does not attempt an in-depth comparison among these different instruments. Instead, it discusses the characteristics and operational theory of the instruments used in the present study.

A Tapered Element Oscillating Microbalance (TEOM)® Series 1400a ambient PM_{10} mass sampler (Rupprecht & Patashnick Co., Inc., Albany, NY, USA, 1996) was used to record real-time PM_{10} concentrations (Patashnick and Rupprecht, 1991). Real-time technology (i.e. TEOM) is well suited to receptor based monitoring approaches because it can detect changes in particulate matter concentrations over the short term. These characteristics tend to be more representative of particulate concentrations in settings where humans spend time (Wallace, 1996; U.S. EPA, 1996), and they are more representative of exposure conditions. The TEOM is the leading instrument worldwide for the continuous monitoring of ambient particulate mass concentration and is used in networks around the world including Brussels, Hong Kong, Madrid, Mexico City, Paris, Santiago, Shanghi, Sydney and Vancouver

(IEA, 1998). In addition, it has been operated at many sites in Alberta including Alberta Environmental Protection's Edmonton Northwest Monitoring Unit (ERMU) since November 1993 (Sandhu, 1998).

The TEOM is able to collect TSP, PM_{10}, $PM_{2.5}$ or PM_1 depending on the inlet size used. For the purpose of this study, only the PM_{10} inlet head (collection of particles <10µm aerodynamic diameter) was used for the entire sampling period. The TEOM has been tested by the U.S. Environmental Protection Agency and has been designated an equivalent method for the determination of 24-hour mean PM_{10} concentrations in ambient air for compliance purposes (U.S. EPA, 1990).

The TEOM is composed of two major components: the control unit and the sensor unit (Figure 7). The control unit houses a microprocessor, flow control hardware, transformers, a gauge to determine filter life and power supplies. The sensor unit houses the mass measurement hardware that enables continuous ambient monitoring. The instrument operates by drawing particle-laden ambient air through an inlet head at a rate of 16.7 liters per minute (lpm). From the inlet head, the flow is isokinetically split into a 3 lpm stream that is sent to the mass transducer and a 13.7 lpm stream that is exhausted (Rupprecht & Patashnick Co., Inc., 1996). Internal temperatures within the instrument are controlled to help minimize the effects of changing ambient conditions. The sample stream is heated to 50°C prior to entering the mass transducer. Operating at this constant temperature ensures that the filter is always above the dew point and maintains a low relative humidity, minimizing water uptake for all ambient temperatures (IEA, 1998).
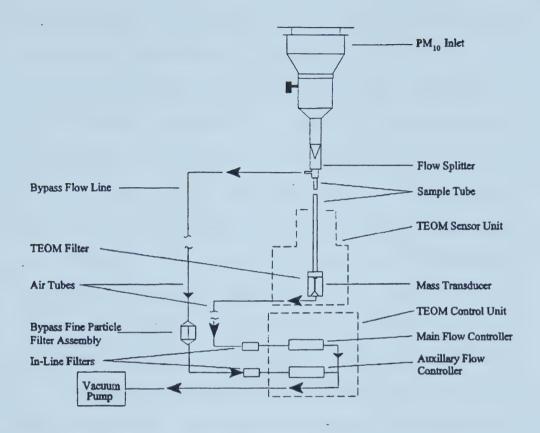
Figure 7. Schematic Diagram of the Assembled TEOM (adapted from U.S. EPA, 1999a).

In the mass transducer, the air passes through an exchangeable filter made of Teflon coated with borosilicate glass at a constant rate of 3 lpm. Particles sampled from the air are continuously collected on the filter that is mounted on the tip of a glass element (microbalance) that oscillates in an applied electric current. The resonating frequency of the element decreases as mass accumulates on the filter. Based upon the direct relationship between mass and frequency, the instrument computes the total mass accumulated on the filter, as well as the mass rate and mass concentration, in real time. In this manner, the filter is weighed continuously (every

two seconds) and the readings of total mass are smoothed exponentially to reduce noise (Rupprecht and Patashnick Co., Inc., 1996).

The TEOM has the ability to record mass measurements every five minutes and it has a reported mass detection limit of 5 μg/m^3 for a 5-minute average and a detection limit of 2 μg/m^3 for a 24-hour time integrated sample at an air-sampling rate of 3 lpm (Chow, 1995; IEA, 1998). Internal memory allows large quantities of data to be stored for later viewing, either on the instrument display or by downloading onto a personal computer. For the present study, the instrument was set to collect the following data every thirty minutes: mass concentration, 30-minute average mass concentration, 1-hour average mass concentration, 24-hour average mass concentration, total mass, ambient temperature and ambient pressure.

The TEOM was fitted into two separate specially designed transportable weather insulated cabinets. The cabinets were constructed of lightweight aluminum and were equipped with handles and locks to provide ease of transport and security during operation. The taller cabinet housed the air-sampling inlet and sensing unit, and the smaller cabinet housed the control unit and air pump. The air pump was kept separate form the sensing unit to prevent vibrations from interfering with the microbalance. The height of the air-sampling inlet was adjusted to 1.9 m or approximate breathing height. Both cabinets were fitted with a temperature controlled heater and fan for air circulation. These devices were set to circulate air and maintain temperatures inside the cabinets at 18°C $\pm$ 5°C. This allowed the TEOM to be used in temperatures down to –20°C. This temperature range was

easily maintained in the taller cabinet housing the sensing unit during sampling periods in which outdoor temperatures ranged from -11°C to 37°C. In addition, the air pump generated a significant amount of heat from operation and maintained temperatures at 15 to 25°C in the smaller cabinet. Electrical wiring and air sampling lines running between the two cabinets (typically placed 0.5 m to 1 m apart) were wrapped in insulation. A 30 m heavy gauge extension cord was used to power the equipment.

In addition to the continuous PM_{10} monitoring, an integrated sampler was needed to collect PM_{10} filter samples. The Portable Minivolume Air Sampler (MiniVol)® made by Airmetrics (Springfield, OR, USA, 1998) was used to collect a multitude of PM_{10} samples (Figure 8). The MiniVol works by drawing air through a size-selective impactor that removes the unwanted larger sizes of particulate and captures the smaller sizes on a filter. The MiniVol is a compact lightweight battery operated portable sampler that can be operated by either AC or DC supplies. These units can be hung from power poles and building walls and do not require complicated sampler siting efforts. This inexpensive sampler contains a sampling head, body and battery pack. The sampling head houses an impactor inlet, preseperator adaptor and a removable filter holder (Figure 8). This is where the filter is situated to collect particulate matter samples. The MiniVol body, which contains a flow meter, timer, tubing and fittings, and pump, is attached to the battery pack.
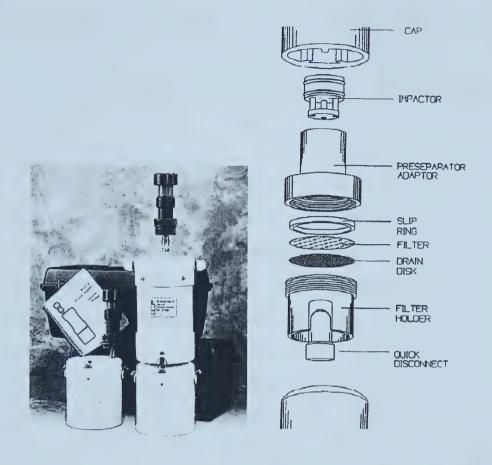
Figure 8. The MiniVol Sampler and a Schematic View of the Sampling Head (adapted from Airmetrics, 1998).

Similar to the TEOM, the MiniVol has a twin cylinder vacuum pump that is designed to pull air at 5 lpm (at standard temperature and pressure) through an impactor that is capable of removing particles larger than the cut-points of either 10 μm or 2.5 μm in aerodynamic diameter (50% effective). This active sampler is operated by the principle of inertial impaction using a single stage impactor with a filter. In this device, the particle-laden air is accelerated through one nozzle and the exiting jet impinges upon a plate. The impactor dimensions are chosen such that

particles smaller than the desired cut-point follow the streamlines as they bend at the impaction plate, while the larger particles with sufficient inertia depart from the streamlines and impact against the plate. The elemental and morphological properties of the deposited material are later analyzed (Airmetrics, 1998; Jones et al., 1998; Tropp et al., 1998).

The method used in this sampling device is a modification of the standard PM_{10} reference method used by the U.S. Environmental Protection Agency as outlined in the Code of Federal Regulations (40 CFR 50, Appendix J) (U.S. EPA, 1999c). The sampler meets the specifications on the air-inlet system, flow control device, flow rate measurement means, and timing control device. However, it is operated at a constant volumetric flow rate of 5 lpm at standard temperature and pressure, which is generally less than the flow rate used by a reference method device. While the MiniVol is not a referenced method sampler, research has demonstrated results that closely match reference methods. There is reported precision of about two percent of the Federal Reference Method (Tropp et al., 1998). In addition, the PM_{10} samplers give good comparisons with the PM_{10} equivalent method dichotomous samplers (Jones et al., 1998). Environment Canada uses the MiniVol as a saturation sampler (i.e. many deployed in a given area), and they have been used extensively in several parts of Alberta under a variety of climatic conditions (Alberta Health, 1997).

Another important consideration is the choice of filter for particulate matter collection using the MiniVol sampler. Ultimately, the choice of filter type in any study depends on the chemical species to be analyzed and the type of analytical

73

methods used. To allow subsequent elemental and microscopic analysis, a filter material with low impurity content, in addition to reasonable strength and collection efficiency, was required for MiniVol sampling in this study. A number of factors, such as filter density, porosity, pH, and chemical and physical composition, play a crucial role in dictating the filter's performance characteristics. Several of these characteristics are important in selecting a filter type; these include: particle sampling efficiency, mechanical stability, chemical stability, temperature stability, blank concentrations, flow resistance and loading capacity, and cost and availability (U.S. EPA, 1999a).

With these performance characteristics in mind, the filters used in the MiniVol sampler for this study were 47 mm diameter Teflo filters (polymethylpentane ring supported Teflon membrane) with 2 μm pore size, made by Gelman Science Inc. (Montreal, Canada). These filters have low blank concentrations, low blank weight and high particle collection efficiency. It has also been documented in previous studies that the use of ringed Teflo filters for elemental analysis shows above average results (Chow, 1995; U.S. EPA, 1996, Chow and Watson, 1998). In addition, membrane filters are best for sampling particulate matter that is to be subsequently analyzed by scanning electron microscopy (IEA, 1998). With scanning electron microscopy the surface of the Teflo membrane filter is smooth enough for particles to be viewed easily whereas fibre filters are far too rough and fibrous to allow the particles to be viewed. Finally, the ringed Teflo filters were more readily available and cost effective.

4.2.2   Protocols

Protocols for the preparation and operation of the MiniVol sampler were developed for the following: cleaning, calibration and routine maintenance; installation of the filters; determination of the flow rate; sampling procedures; filter retrieval; and special protocols for replicate samples, control blanks and field blanks (Airmetrics, 1998). Extensive protocols for the handling, exchanging and transporting of filters were not required for the TEOM. Therefore, the equipment was calibrated, assembled and operated according to standard operational manual specifications (Rupprecht and Patashnick Co., Inc., 1996). All sampling protocols were developed prior to fieldwork commencing to ensure that they were consistently and strictly followed.

Cleaning, Calibration, and Routine Maintenance

1. The MiniVol was calibrated according to operation manual specifications before each sampling season.

2. Cleaning and greasing of each impactor was done every seventh day or when the impactor was visibly dirty, whichever came first.

Installing Filters

1. Clean new filters were placed onto petri-slides. Sample numbers were randomly recorded on the petri-slides for easy identification in the field. These were stored in a sealed plastic container and placed in a laboratory room with constant temperature and humidity.

2. The filter installation was done under a fume-hood in a laboratory to reduce dust fall.

3. The filter cassette was placed in a cassette shoe and the top ring was removed.

4. The next filter in sequential order (randomly determined before sampling) was selected and the cover from the petri-slide was removed.

5. The filter was inspected for pinholes or cracks. If one was present, another filter was randomly selected.

6. Using Teflon forceps (which were dipped in methanol and allowed to dry) the filter was installed onto the drain disk that rests on the filter support grid, with care taken not to shred or damage the edges of the filter.

7. The top ring was replaced and the filter was placed in the filter holder.

8. The preseperator adapter was screwed down.

9. An identifying tag was placed on the filter holder.

10. The filter number and filter type (i.e. sample, control blank, field blank or replicate) was recorded on an Air Sampling Field Log form (Appendix 8.1).

11. A clean, plastic bag was placed over the top of the preseperator adapter inlet and a rain cap was pushed snugly into place over the bag.

12. The entire assembly was placed into a second larger plastic bag and put into a Thermos® box.

13. The filter assembly was kept in a vertical position at all times.

Determining Flow Rate

1. The weather data for each sampling day was obtained from Environment Canada. The temperature, atmospheric pressure, windspeed and direction,

76

precipitation events, relative humidity and any other relevant information were recorded on the Air Sampling Field Log form (Appendix 8.1) for the day's filter.

2. The flow setting was calculated via a Microsoft Excel® spreadsheet following the directions in the MiniVol Operation Manual.

3. The desired flow was recorded on the Air Sampling Field Log form (Appendix 8.1).

Sampling Procedures

1. All exchanges took place at 12:00 p.m.

2. After the filter assembly was transported to the field, it was placed on a firm level surface.

3. The sampler was removed from the mounting cradle and set on a level surface.

4. The cap of the bale assembly bar was unscrewed and the bar removed.

5. The pump and timer assembly was lifted out.

6. The sampler faceplate was checked for any error conditions.

7. The correct time and day on the LCD was verified.

8. The clock time, elapsed time and the ending flow rate were recorded on the appropriate Air Sample Field Log form (Appendix 8.1) for that sample.

9. The on/auto/off button was pressed twice to stop the pump.

10. The ending weather information was recorded on the Air Sampling Field Log form (Appendix 8.1) for that sample.

11. The MiniVol operating condition, the TEOM operating condition and any other observations (i.e. potential sources) were recorded on the Air Sampling Field Log form (Appendix 8.1) for that sample.

12. The exposed assembly was removed. A crosscheck of the exposed filter number was performed with the filter number recorded on the Air Sampling Field Log form (Appendix 8.1) for the run just completed.

13. The exposed assembly was placed in a clean, plastic bag over the top of the preseperator adapter inlet and a rain cap was pushed snugly into place over the bag. The entire assembly was placed into a second larger plastic bag and put into a Thermos® box. The filter assembly was kept in a vertical position at all times.

14. The battery pack was changed.

15. The on/auto/off button was pressed to start the pump.

16. The flow was adjusted to the flow determined for that filter run.

17. The pump was inspected for leaks and a flow test was performed by placing a hand over the pump inlet (pump should go to zero).

18. The pump was turned off.

19. The clean preseperator/filter holder assembly was removed from the plastic transport bag and the protective plastic bag under the rain cap was removed.

20. The new assembly was placed onto the filter inlet.

21. The pump was turned on.

22. The following information was recorded on the Air Sampling Field Log form (Appendix 8.1) for the new filter run: sampler ID, battery ID, clock time, elapsed time, MiniVol and TEOM operating conditions, and any relevant observations.

23. The pump and timer assembly was placed back into the sampler body. The bale assembly bar was replaced.

24. The sampler was placed on the mounting cradle.

25. The MiniVol was allowed to sample for 24 hours.

Filter Retrieval

1. The filter holder assembly was transported back to the laboratory.

2. Filter retrieval was done under a fume-hood in the laboratory.

3. The appropriate petri-slide was located.

4. The plastic bags were removed from the filter holder assembly.

5. The preseperator assembly was removed.

6. The filter was inspected for pinholes and cracks. Observations of any visible local concentrations of deposits on the filter or other irregularities were made on the Air Sampling Field Log form (Appendix 8.1) for that sample.

7. The filter cassette was removed and placed in the cassette shoe. The top ring was removed.

8. Using Teflon forceps (which were dipped in methanol and allowed to dry) the filter was removed from the drain disk which rests on the filter support grid, with care taken not to shred or damage the edges of the filter and keeping it horizontal at all times.

9. The filter was placed into the appropriate petri-slide.

10. The petri-slide was capped and wrapped with a thin paraffin wax.

11. The petri-slide was placed into a Tupperware® container and secured with bubblewrap.

12. The old ID Tag from the Filter Holder Assembly was removed and discarded.

Replicates

1. Three replicate samples were taken during each sampling season for a total of six. The days that replicate sampling was to be performed were randomly decided before each sampling season.

2. The procedures for replicates were exactly the same for the other samples except that sampling was conducted using a second MiniVol that was co-located beside the first MiniVol.

Control Blanks

1. One control blank was performed for each sampling season for a total of two. These were taken at the start of the sampling seasons.

2. This was done by simply selecting the first filter for each sampling season and marking it as a control blank. The filter was not taken out of the petri-slide but was instead stored in a Tupperware® container in the laboratory room until needed for analysis.

Field Blanks

1. Three field blanks were performed during each sampling season for a total of six.

2. The days to perform field blanks were randomly decided before each sampling season.

3. The procedures for field blanks were exactly the same as for the other samples except that no actual sampling took place. All handling, transporting, and assembling procedures were followed, but the MiniVol was not turned on. Instead the filter was removed from the MiniVol and transported, retrieved and stored according to normal procedures.

4.2.3 Site Location

As with any type of air sampling study in which sample data are used to draw conclusions about a general population, the validity of the conclusions depends on the representativeness of the sample data. Therefore, the primary goal of a sampling project is to select a site where the collected particulate is representative of the monitored area. The importance of collecting a representative sample cannot be overemphasized, because if a sample is not representative of the larger population being studied, the resulting conclusions will not be valid no matter how well they are analyzed or interpreted. When locating potential sites to perform PM_{10} sampling and monitoring where the TEOM and MiniVol could be co-located and operated for the entire sampling duration two factors had to be considered: the type of sampling to be performed and the siting criteria required.

Sampling approaches vary greatly, depending on the objectives of the study and the complexity of the sampling site. There are two primary sampling approaches: random and judgmental. Random sampling is performed by simply randomly selecting a location from those available to sample for particulate matter. This type of sampling allows the largest number of samples to be collected and provides the least amount of bias. However, random sampling, while ideal for receptor modeling, is not always practical because proper siting generally requires power, security, and some minimal separation from nearby obstacles. In addition, prior knowledge can ensure that as much useful data as possible is collected. Therefore, judgmental sampling is always used for monitoring networks of criteria pollutants such as

particulate matter (Watson et al., 1997). Judgmental sampling uses background knowledge of source emissions, sensitive receptor locations and meteorological conditions to locate appropriate sampling sites.

Siting procedures followed in this study for the equipment conformed to the U.S. Environmental Protection Agency requirements as stated in the U.S. Code of Federal Regulations (40 CFR part 58, Appendix E) (U.S. EPA, 1999d). Basic siting criteria for the placement of ambient air samplers include the following:

- The sampler inlet must be 2 m – 7 m above the ground.

- The sampler must be located 2 m – 10 m away from any roadways.

- The sampler should be placed at least 20 m from the dripline of any tree and must be 10 m from the dripline when the tree acts as an obstruction.

- The sampler must be located away from obstacles such as buildings, so that the distance between obstacles and the sampler is at least twice the height that the obstacle protrudes above the sampler.

- The sampler must have unrestricted airflow 270 degrees around the inlet.

- No furnace or incineration flues should be nearby.

- Sampler inlet must be at least 2 m but not more than 4 m from any co-located PM_{10} sampler.

This list is not a complete listing of siting requirements. Additional factors not specified in the Code of Federal Regulations must also be considered in determining where the sampler is deployed. These factors include accessibility under all weather conditions, availability of adequate electricity and security of the

personnel and equipment. With these siting requirements (both required and other) in mind, a sampling site was chosen which best satisfied the requirements while still remaining as representative as possible. In addition, the site was chosen judgmentally so that the most useful data would be obtained based on knowledge of potential sources and prevailing meteorological conditions.

The site selected was located in approximately the center of the community on a residential lot (Figure 9). This site was judged to be in a prime location to be representative of both the conditions in a regional background setting in Alberta and of the conditions in the rural community of Devon. Some potential near field open sources of particulate matter at this site included: an active construction site approximately 200 m away, a gravel road approximately 100 m away, a busy paved highway approximately 300 m away and a dirt garden within the lot. As there were no local point sources of particulate matter in the community, the only other possible emissions were those from local open sources (i.e. agricultural activity and river bed dust), local non-point sources (i.e. combustion and vehicle emissions), and long-range transport from urban centers and regional industry.

The site was secure, had a power supply, and access was granted for the entire sampling period. In addition, on two sides of the site there were only open spaces with vegetative cover. This was important because not only were there no obstructions on those sides, but the vegetative cover helped to ensure that the impact of near-field windblown dust was kept to a minimum. The TEOM and MiniVol were co-located in the back corner of the residential lot so as not to be disturbed (Figure 10).
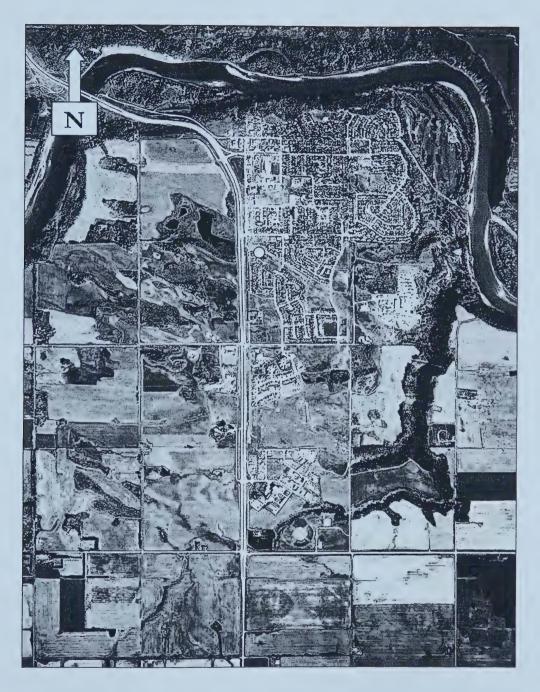
Figure 9. Overview of Sampling Site in Devon, Alberta.

Note: ○ indicates the sampling site.

Figure 10. TEOM and MiniVol Co-located at Sampling Site.

This site was judged the best of those that were surveyed, but it had a number of limitations that must be noted. Firstly, a 1.5 m fence surrounding the lot may have caused potential interference with the collection of the particulate matter. However, as the samplers were placed 1.5 m in height, the impact was judged to be minimal. Secondly, there was a large coniferous tree located within the lot that was not the required 10 m away from the sampler as specified in the Code of Federal Regulations. The effect from this obstruction was minimal, however, because the tree was narrow enough to not have a large impact. In addition, the samplers were positioned as far away as possible (i.e. 8 m) so that the impact was further reduced.

Finally, as the site was located on a residential lot, the house itself could have had some impact by acting as a barrier. However, this impact was minor because the house was short (i.e. 10 m) and distant (i.e. 25 m). The equipment assembly, including appropriate spacing and vertical and horizontal probe placement, was strictly adhered to as stated in the U.S. Code of Federal Regulations (40 CFR part 58, Appendix E) (U.S. EPA, 1999d).

4.2.4 Sampling Schedule

With the sampling equipment and receptor location identified, a schedule was developed that would account for sampling during two seasons in 2000 (summer and fall). The purpose was to sample and monitor PM_{10} at the selected representative site in Devon for a total of twenty-two days in both August and October. This ensured every day of the week was accounted for at least three times in each of two seasons. In this way, seasonal, weekly and diurnal temporal variability would be accounted for. The TEOM was transported and assembled at the site and operated continuously from August 1, 2000 (beginning at noon) to August 23, 2000 (ending at noon) and from October 3, 2000 (beginning at noon) to October 25 (ending at noon).

The sampling schedule for the MiniVol was somewhat more complex as it entailed filter exchanges every 24 hours (precisely at noon) in addition to accommodating control blanks, filed blanks and replicates. The days on which to perform control blanks, filed blanks and replicates were chosen randomly at the beginning of the study. The result was the sample schedule shown in Table 7. This

sampling schedule provided twenty-two MiniVol 24-hour filter samples for each season for a total of forty-four. It also provided one control blank for each season, three field blanks for each season, and three replicates for each season. The samples, blanks and replicates were taken according to the protocols outlined in Section 4.2.2 Protocols and stored until required for subsequent laboratory analysis.

Table 7. PM$_{10}$ Sampling Schedule.

Sample Type		Season	
		Summer (August)	Fall (October)
Sample	Start	August 1, 2000	October 3, 2000
	End	August 23, 2000	October 25, 2000
Control Blank		August 1, 2000	October 3, 2000
Field Blank		August 1, 2000 August 11, 2000 August 23, 2000	October 3, 2000 October 13, 2000 October 25, 2000
Replicate		August 3, 2000 August 14, 2000 August 21, 2000	October 4, 2000 October 16, 2000 October 23, 2000

4.3   Laboratory Analysis

4.3.1   Methods

Many analytical methods exist to characterize particulate matter collected on a filter substrate and each has its own attributes, specificities, advantages and disadvantages. Though several methods are multi-species (able to quantify a number of different chemical components simultaneously) no single method is sufficient to quantify both the majority of the collected particulate matter mass and those components which serve to identify and quantify source contributions. To accomplish the mathematical deconvolution upon which receptor models are based, a relatively large data set is necessary. Many elemental concentration determinations in a large number of samples are required and consequently a multi-elemental analytical technique is desirable. Furthermore, the relatively small amounts of mass collected on filters in sampling periods of practical length requires a non-destructive and very sensitive technique.

The most common methods of analysis for receptor modeling are the multi-elemental techniques such as Instrumental Neutron Activation Analysis (Zoller and Gordon, 1970; Gladney et al., 1974; Hopke et al., 1976; Mizohata and Mamuro, 1979; Kowalczyk et al., 1978, 1982; Olmez, 1989; Rizzio et al., 1999; Salma and Zemplem-Papp, 1999) and X-Ray Fluorescence (Dzubay and Stevens, 1975; Dzubay, 1977; Lewis and Macias, 1980; Price et al., 1982; Dzubay et al., 1988; Glover et al., 1991; Schmeling et al., 1997). Instrumental Neutron Activation Analysis (INAA) bombards a sample with neutrons and the radioactivity induced is subsequently

measured and used to quantify elemental contributions. INAA has the advantage of higher sensitivity compared to some other methods, a fact that makes it attractive for sampling trace elements found in extremely low concentrations. It is also relatively non-destructive and requires minimal sample preparation. Limitations of this method include the fact that elements such as sulphur, lead and cadmium cannot be determined, as well as that INAA is more expensive than many other methods. In addition, to use this method an optimal loading of >100 $\mu g/cm^2$ is generally required (Gordon et al, 1984). This optimal loading level is usually not achieved when using short duration and low volume sampling in a regional background airshed as in the present study.

In X-Ray Fluorescence (XRF) a beam of X-rays irradiates a sample and causes each element in the sample to emit characteristic X-rays that are detected by a solid-state detector or a crystal spectrometer. The characteristic X-ray is used to identify the element and the intensity is used to quantify the concentration of the measured element. This method has the advantages of being non-destructive, providing immediate results and having low equipment cost. However, it requires a thin collection deposit (i.e. 10 to 50 $\mu g/cm^2$), involves complex matrix corrections and elements lighter than aluminum are often difficult to determine because of their low fluorescent yields and particularly because of the strong absorption of fluorescent X-rays by the substrate on which they are collected (U.S. EPA, 1999a).

Atomic Absorption Spectroscopy (AAS) has occasionally been used as the primary method for receptor modeling studies (Scheff et al., 1984) and metal content

determinations (Beceriro-Gonzalez et al., 1997) but is more commonly used as a supplementary technique for elements not amenable to analysis by one of the multi-elemental techniques (Kowalczyk et al., 1982; Rizzio et al., 2000). In this method, the metals in the sample are extracted into a solution and subsequently vaporized in a flame. A light beam with a wavelength matching the absorption wavelength of the metal of interest passes through the vaporized sample. The light attenuated by the sample is then measured and the amount of the metal present is determined using Beer's Law (Koutrakis and Sioutas, 1996). AAS has the advantage of being able to accurately measure elements such as cadmium, lead, zinc and magnesium. However, the necessary dissolution of collected particulate and the manipulation of a solution of trace elements is not a trivial thing. Furthermore, AAS can only analyze one element at a time thus rendering the analysis of an extensive set of elements prohibitively time consuming.

Some work on trace element pollutant analysis has also been performed using Proton Induced X-Ray Emission (PIXE) (Heidam, 1981; Van Borm et al., 1990; Flores et al., 1999). This technique is a non-destructive, multi-elemental procedure in which protons excite the atoms of a sample and the characteristic emitted X-rays are used to identify and quantify different elements in the sample. PIXE is capable of measuring smaller quantities of particulate matter, although it has the same limitations as with XRF concerning light elements. In addition, facilities for this method are expensive and not common and it is less suitable for routine filter analysis than other multi-elemental methods because of more complicated sample preparation (U.S. EPA, 1994).

Other analytical methods have also been used such as Inductively Coupled Plasma/Mass Spectrometry (ICP/MS) (Broekaert et al., 1982; Janssen et al., 1997). In ICP/MS analysis, the sample is excited using an argon plasma torch to generate elemental ions for separation and identification by mass spectrometry. This analysis allows many more than sixty elements to be determined simultaneously and even the isotopes of an element can be determined. However, ICP/MS analysis is time consuming because the sample must be extracted or digested and the analysis is destructive. In addition, the procedure is very costly and its documented applications are the lowest among all the potential techniques (U.S. EPA, 1999a).

There have been several reports of Energy Dispersive X-Ray spectrometry (EDX) being used in conjunction with Scanning Electron Microscopy (SEM) (Linton et al., 1980; Casuccio and Janocko, 1981; Shaw, 1983; Post and Buseck, 1984; Saucy et al., 1987; Anderson et al., 1988; Dzubay and Mamane, 1989; Hamilton et al., 1994). Scanning Electron Microscopy with Energy Dispersive X-Ray spectrometry or SEM-EDX uses a computer controlled scanning electron microscope equipped with image analysis software to determine the size and shape of a moderate number of particles and EDX to provide qualitative and a moderately sensitive quantitative elemental analysis in a similar manner as XRF analysis (for elemental concentrations in a particle of >0.1% (Henry, 1985)). SEM-EDX represents a powerful tool for the identification and classification of airborne particles.

The primary advantage of the SEM-EDX technique is the ability to characterize individual particles both chemically and physically, and thus reduce problems of compositional collinearity between contributing sources. This is an

91

important factor for differentiating particles with similar compositions originating from different sources such as coal flyash and crustal material. The Expert Panel on the U.S. Environmental Protection Agency $PM_{2.5}$ Chemical Speciation Network has recommended using the SEM-EDX for analysis of air filters (U.S. EPA, 1999b). The panel found that microscopic techniques could be used to characterize both the morphology and the chemical composition of individual particles (Koutrakis, 1998). In addition, they stress the development of SEM-EDX for quantitative source apportionment. The SEM-EDX is very useful for receptor modeling because the EDX can be used to detect light elements that are often used as elemental tracers of potential sources, in addition to those elements typically characterized by XRF, and with a lower threshold limit of <1 wt % (Woldseth, 1973; Chow and Watson, 1998).

Another benefit of using the SEM is that it can provide an estimate of the contribution of biological or carbonaceous particles to particulate matter levels (Hamilton et al., 1994). These particles cannot be analyzed with normal analytical techniques because they contain only light elements (i.e. carbon, hydrogen, nitrogen and oxygen) that emit X-rays which cannot be detected. These types of particles are often divided into two groups: organics (insect parts, hairs, plant debris, wood parts, pollen, spores and bacteria) and elemental (charred plant and wood debris from residential burning, forest fires and agricultural burning). Since the mass contribution of biological particles to the total airborne concentration in an area can be substantial, they must be accounted for in some manner. The SEM is able to do this by providing the means to identify and characterize these particles based on their morphology.

The disadvantages of the SEM-EDX technique include poor quantitative sensitivity (Linton et al., 1980) and practical difficulties such as excessive time for a representative analysis and the occurrence of both particle damage and compositional changes during analysis (Post and Buseck, 1984). In addition, the EDX technique often results in potential spectral interferences requiring complex spectral deconvolution procedures. Advances in microscopic techniques, particularly in sample analysis software, now permit collection of reasonably large datasets of individual particle morphology and composition. This technology has helped to overcome the sometimes-problematic issue of only being able to analyze a moderate number of particles in a reasonable time frame with the conventional SEM-EDX technique. To illustrate this point, an increasing number of studies in recent years (Rojas et al., 1990; Van Borm et al., 1989; Xhoffer et al., 1991) have employed electron probe microanalysis to analyze individual particles. However, these technologies are very expensive, still in the developmental phase and not readily available and, thus, could not be employed in this study.

Based on the above considerations, the SEM-JEOL 6301F (Field Emission SEM) with the attachments Light Element Energy Dispersive X-Ray Analysis (EDX), Backscattered Electron Imaging (BSE), Cryostage (Cryo) and Image Analysis was used in the present study for the analysis of the PM_{10} filter samples. Detailed protocols for the preparation and analysis of filter samples using this analytical technique are described in Section 4.3.2 Protocols; however, a brief description of the operational theory is given below.

When a sample was prepared for the SEM-EDX, the 47 mm Teflon filter needed to be mounted on a 13 mm plate. This was accomplished in a laminar-flow hood as to prevent external loading onto the filters. The filters were mounted with carbon tape and then coated with gold for better transmission and imagery. Following a microscopic receptor model, the object was to analyze enough random particles to be representative of the entire filter (Cooper and Watson, 1980). Therefore, when analyzing a filter, as many particles as practicable were chosen at random for quantification analysis. A particle would be bombarded with an electron beam, and the specimen would then release some absorbed energy as X-rays. Much of the time, the energy was the result of random changes in the speed of an electron. However, when this interaction removes an electron from a specimen's atom, frequently an electron from an outer shell (or orbital) occupies the vacancy. When an outer electron occupies this vacancy, it must lose a specific amount of energy to occupy the closer shell. This amount is readily predicted by the Laws of Quantum Mechanics and usually much of the energy is emitted in the form of X-rays. The X-rays of specific energy are detected, relating directly to specific elements. The computer can interpret the results into quantitative measurements (Woldseth, 1973). In addition to the elemental quantification of particles, each morphologically (size and shape) different type of particle was recorded, described and classified.

4.3.2   Protocols

1. Filter preparation was performed in a laminar-flow hood to prevent dust fall on the filter.

2. The 47 mm Teflon filters were mounted on a 13 mm plate with carbon tape, with the excess filter cut out, leaving approximately 13 mm of exposed filter surface. In the interest of consistency, only the center of each filter was used to represent the entire filter.

3. The filters were pre-coated with gold for better transmission and imagery.

4. When analyzing a filter, particles were chosen at random by an outside party for quantification analysis. The purpose of this was to reduce bias when selecting particles to represent the entire filter.

5. The procedure for particle analysis was as follows:

    *   Each filter was divided into 4 quadrants.

    *   Multiple random areas were chosen for each quadrant. After selecting a random area, the SEM was set at full magnification and then slowly reduced. The first recognizable particle was analyzed and a new area was then chosen.

    *   A maximum of 3 particles from each quadrant were analyzed.

    *   A total of 10 particles for each filter were analyzed. The purpose of this was to save time and money while at the same time still analyzing enough particles on each filter to adequately represent the entire filter.

6. All particles were candidate particles for analysis regardless of size, shape, or composition. However, as the EDX is incapable of accurately analyzing biological particles, only non-biological particles were analyzed.

7. The following procedure was used to account for biological particles:

    • A particle was identified as biological when it was either visually recognized as such or when it was analyzed using the EDX and the only elemental spectral peak was gold. If the gold peak is the only one present, it can be assumed that the particle consists solely of carbon or other light elements, but in insufficient quantities to be noticed above background (Hopke, 1985).

    • The number of biological particles encountered while analyzing the 10 required particles for each filter was noted.

    • The amount of biological particles on each filter was presented as a ratio between the number of biological particles and the number of analyzed particles (i.e. 10).

    • A large ratio would indicate a large amount of biological particles present on that filter and a small ratio would indicate a small amount of biological particles present on that filter.

8. For each particle analyzed the following were recorded on an SEM-EDX PM_{10} Analysis Data Log from (Appendix 8.1): elemental spectra, elemental abundance table and a description of the particle.

9. For each sampling season the following were recorded on an SEM-EDX PM_{10} Analysis Data Log from (Appendix 8.1):

- A SEM photograph of the overview of one filter.

- SEM photographs of every particle analyzed on one filter.

- SEM photographs, elemental abundance tables and elemental spectral graphs of one of every different type of particle encountered during the entire analysis procedure (including biological particles).

10. Control blanks and field blanks were analyzed in the same way as the other filters and SEM photographs were taken of all blanks. Any particles discovered on the blanks suggested procedural or equipment error.

11. Elemental composition (abundance percentage) for each filter was determined by averaging the elemental compositions of all 10 particles analyzed on each filter. This number of particles was used as a standard minimum because it could ensure an adequate statistical population (when budget and time constraints were considered) to represent conditions at the time the sample was taken. The same number of particles was analyzed on each filter to ensure that an equal population represented every filter.

12. Replicates were analyzed in the same manner as their counterpart samples. If the replicate and the corresponding sample represented the same time frame they were analyzed for statistical similarity. The elemental composition of the replicate and the corresponding sample were then averaged and used to represent the sampling period. If the time frames were different for the sample and replicate, the one that was closest to 24 hours was used to represent that sampling day.

4.4   Data Analysis

4.4.1   Methods

This study employed a multivariate receptor modeling technique using the available elemental data provided by the SEM-EDX analysis to apportion the PM_{10} found at the receptor location among probable sources. Specifically, the multivariate receptor modeling technique used is known as principle component analysis (PCA). The PCA model is a statistical technique that assumes that temporal variations in observable variables are merely manifestations of the influences of a limited number of "true" underlying factors. PCA takes a large data set of interrelated variables and reduces the dimensionality to a small workable number of independent variables that are then used to explain the potential underlying relationship between the data. To achieve this, factors or principle components are constructed according to a linear combination of the original variables, so that the newly formed factors are uncorrelated and they are constructed with decreasing degree of importance. The factors obtained in this way embody the linear independent variance present in the data of the original variables and are generally representative of the sources in the system.

The usefulness of the PCA technique has been well recognized since it was first introduced over a century ago by Pearson (1898); however, only recently, since the use of computers has greatly increased its ease, has it been applied so readily (Basilevsky, 1994). The potential of this technique in particulate matter source apportionment studies has been fully demonstrated (Henry and Hidy, 1979; Cooper

and Watson, 1980; Roscoe et al. 1982; Pace, 1985; Thurston and Spengler, 1985; Watson, 1988; Harrison et al., 1996; Harrison et al., 1997; Biegalski et al., 1998). The basic concept of PCA, when applied in particulate matter source apportionment studies, is to unravel the seemingly unrelated elemental data to reveal a new related data set based on the variations in abundances of elements detected at a receptor location over time. This related data set could then be used to find statistically independent source tracers that can identify the nature of each source category.

The specific details of the mathematical processes involved with the PCA technique can be found in a number of statistical texts (Dillon and Goldstein, 1984; Jolliffe, 1986; Basilevsky, 1994). However, a brief overview of how the data were prepared and applied in the present study is given below. The data used in any PCA are composed of the elemental concentrations of many samples acquired under different circumstances. In this study, the elemental concentrations measured for samples at one location at various times as determined by the SEM-EDX analysis were used. To prepare for the PCA, the data were placed in a data matrix so that the elemental concentrations made up the matrix rows and the samples made up the matrix columns. The average value of the observable variable, in this case the element, was calculated by summing across the ith row and dividing by the number of columns. Once the average values were calculated, standard deviations of the variables could also be determined. With the data in matrix form and the average and standard deviation of each variable known, the PCA model could then be performed.

The first step in the PCA was to transform the elemental data into a dimensionless standardized form known as a z-score:

$$z_{ik} = \frac{(x_{ik} - \overline{x_i})}{\sigma_i}$$
Equation (4)

where i = 1, 2, ... n, the total number of elements used in the analysis; k = 1, 2, ... m, the total number of observations (i.e. samples); z_{ik} (z-score) is the standardized value of element i for observation k; x_{ik} is the mass concentration of that element for that observation; $\overline{x_i}$ is the mean mass concentration for the ith element over all observations; and σ_i is the standard deviation of the distribution of mass concentrations of the ith element. If this standardization were not completed, there would be an inclination to de-emphasize those variables with smaller absolute magnitudes during the ensuing PCA. Hence, standardizing the data prior to the PCA tends to equalize the opportunity of both large and small magnitude variables to influence the analysis (Thurston and Spengler, 1985).

Having transformed the data into a dimensionless standardized form, the PCA technique was employed. Mathematically, PCA assumes that the total mass concentration of each element is made up of the sum of elemental contributions from each of j underlying factors or sources of variation. Hence,

$$z_{ik} = \sum_{j=1}^{P} a_{ij} f_{jk}$$
Equation (5)

where f_{jk} is the j factor's value for observation k; j = 1, 2, ... p, the number of underlying factors influencing the data; and a_{ij} is the loading matrix of the factors. In other words, the standardized data are represented as the product of two components: the factor loadings, a_{ij}, which represent the correlation coefficients

between the factors and the original variables, and the factor scores, f_{jk}, which are indicative of the importance of each factor to each sample (Roscoe et al., 1982).

The primary objective of applying PCA is to obtain a limited number of factors for each data set that explain a majority of the total variance in the original variables. In order for the PCA reduction in dimensionality to be valuable, the factors must have a simple substantive interpretation. However, it has been found that several different underlying sources of variation may be incorporated into any one unrotated factor (Roscoe et al., 1982). Thus, the factors resulting from an unrotated PCA often do not have straightforward or unique explanations. For this reason, PCA usually includes a subsequent rotation of a limited number of factors, resulting in factors that have been found to be more representative of individual underlying sources of variation. This, in turn, results in more interpretable and useful factors. The merits of PCA rotation in analyzing particulate matter data have been discussed in the literature by Henry and Hidy (1981), Thurston (1981), Hopke (1982), and Thurston and Spengler (1985).

Many methods are available for the rotation of the factors; however, one of the most widely used and accepted methods is Varimax. A Varimax rotation is an orthogonal rotation method that minimizes the number of variables that have high loadings on each factor, thus simplifying the interpretation of the factors. Based upon these considerations, an orthogonal Varimax rotation was employed in the analysis of the elemental data set in this study.

One difficulty encountered in the method described above is the selection of the number of factors that are to be retained in the rotation procedure. The extent of

debate on this subject renders the decision an interpretive one (Hopke, 1981; Richman, 1985, 1986; Ashbaugh et al., 1985; Hopke and Malinowski, 1986) although a starting point would be to retain all factors giving an eigenvalue greater than unity on the grounds that no common factor should account for less variance than one of the original variables (Heidam, 1982). Therefore, for the purposes of this study, only factors with an eigenvalue above one were kept for rotation.

Upon completion of the rotation, PCA replaces the set of intercorrelated variables with a set of uncorrelated factors that are linear combinations of the original variables. The first factor is the linear combination of variables that explains or accounts for a maximum of the variability of the original variables. The second factor is the linear combination, uncorrelated with the first factor, which explains a maximum of the total variability not already accounted for by the first factor. The third, fourth, etc., factors are explained similarly. The factors are convenient to work with because they are statistically independent, and, typically, the first few factors explain the majority of the variability of the whole data set (Henry and Hidy, 1979).

Following the PCA, interactions of the various elements with the factors were investigated to determine logical sources. The interpretation of the underlying origin of the factors has been traditionally limited to the inspection of the factor loadings only. Since the factor loadings are the correlation coefficients between the original variables and the factors, they provide the key information as to the nature of the factor. For the interpretation of the factor loadings, Table 8 is often used as a useful guide (Henry and Hidy, 1979).

Table 8. Interpretation of Factor Loadings (Henry and Hidy, 1979).

Value of Factor Loading (a_{ij})	Interpretation
-0.2 to +0.2	Almost no correlation to the factor.
±0.2 to ±0.9	Moving incrementally towards a strong correlation to the factor.
±0.9 to ±1.0	Strong correlation to the factor.

Elements that have high loadings for a particular factor were used to construct an elemental profile for a source or used as a unique tracer for a source. This profile or tracer was then compared with those found in similar studies, relevant literature, and particulate matter databases to label each factor as a specific source or a source category. It is usually the case that as many as five to eight individual source types can be identified with this method (Harrison et al., 1996).

In order to find statistically independent source profiles or tracers there should be a large number of samples in the analysis. Some have stated that at least 40 ambient air samples must be collected and analyzed to give a reliable, statistically independent result (Pace, 1985), while others have maintained there should usually be at least 50 (Harrison et al., 1997). It is generally accepted, however, that to obtain the most accurate and reliable results possible the number of samples collected and analyzed should ideally be equal to or greater than the number of elements used in the analysis plus 50 (i.e. $m \geq n + 50$) (Thurston and Spengler, 1985). In the present study, 44 ambient air samples were analyzed and used for subsequent PCA. As

shown later, this number of air samples was sufficiently able to explain a large majority of variance of the original dataset due in part to the low number of elements used in the analysis.

4.4.2 Receptor Models for Regional Background Studies

Multivariant receptor models, including principle component analysis (PCA), have been applied successfully in many studies where the airshed in question is considered an urban (or industrial) area and is therefore affected by local anthropogenic point sources of particulate matter (Thurston and Spengler, 1985; Van Borm et al., 1990; Ehrman et al., 1992; Kartal et al., 1993; Fung and Wong, 1995; Harrison et al., 1997; Alves et al., 1998a; Bandhu et al., 2000). Despite this success, PCA has only been applied in a few studies concerning the source apportionment of particulate matter in regional background settings (Parekh and Husain, 1981; Shaw and Paur, 1983; Stevens et al., 1984; Tuncel et al., 1985). The outcomes of these studies have not been as successful as urban studies in definitively explaining the sources of the particulate matter in their airsheds because they create a new set of interpretive problems. As opposed to urban studies where probable sources of particulate matter can be predicted with a certain degree of accuracy, regional background studies do not have that benefit. These studies are considered regional background for the very reason that only uncertain natural, local non-point and long-range regional sources of particulate matter affect them.

Particulate matter can contain all elements; no true tracers, or elements unique to a specific source exist (Rahn and Lowenthal, 1984). But it is reasonable to

expect the proportions of at least some elements to vary with differing sources of particulate matter because different sources have different mixes of origins, processes and controls. This is the foundation of receptor modeling and the reason why it has been successful in studies where sources, and their elemental tracers, can be predicted and used as a basis for analysis. However, when sources are unknown, as with regional background studies, the number of elemental tracers, the magnitude of their differences and the elements involved cannot be predicted; they must instead be determined empirically. The keys to deriving regional background tracers or signatures are finding the correct elements from those available and handling the data with the appropriate statistical techniques so that important information is not lost.

In general, regional background tracers are constructed and used quite differently from urban tracers. Elemental signatures used to deduce sources of urban particulate matter by receptor-oriented techniques are usually derived for either known point sources or specific types of sources. Regional background aerosols, by contrast, are mixes of many unknown sources and should thus resemble one another much more than signatures within an urban region should. Similarities among pollutant sources have been recognized for years, and many have doubted whether useful regional differences could be found. An example of this confusion is the classic problem of distinguishing between soil and emissions from coal combustion, which both contain very similar elemental profiles (Gordon et al., 1981). The marker element approach sometimes used in urban studies (where the contribution of a source is evaluated by a single element) cannot be used with regional background

studies because of the inability to identify all possible sources before analysis with a certain degree of confidence. The opposite approach, constructing signatures from all available elements, is practiced in some urban studies but adds too much noise and uncertainty when applied to regional background studies because of the great similarities between sources. The best approach for this type of study is to compromise between the two – sequentially eliminate elements from further steps in the PCA, in order to limit regional background signatures to those few elements with the greatest tracer power, while at the same time ensuring that all possible sources are accounted for with a high degree of certainty (i.e. a large proportion of the variability explained). Similar processes whereby elements are eliminated have been demonstrated in other studies and have been shown to be useful (Shaw, 1983; Stevens et al., 1984; Rahn and Lowenthal, 1984; Hidy, 1988; Sharma and Singh, 1991; Xhoffer et al., 1991; Harrison et al., 1997; Alves et al., 1998b).

As one of the objectives of this study was to determine the sources of regional background particulate matter in Alberta, a protocol was developed so that the number and identity of sources could be accurately identified using the least number of tracer elements thereby eliminating statistical uncertainty and noise. Elements and signatures must meet several requirements before they can be used in a regional background tracer study: the element should be emitted stably and in a measurable concentration, the elements should be distinctive to a certain source, and the association of the tracer to a source should be strong (Rahn and Lowenthal, 1984). A step-wise sequential process was created to eliminate elements that do not meet these criteria. The PCA, as described in the previous section, was initially conducted using

data from every particle elementally analyzed by the SEM-EDX. Elements and their data were then eliminated incrementally and the analysis repeated until only those elements that did not possess any of these characteristics remained:

1. Elements that had low abundances or that were thought to have been unreliably determined by the SEM-EDX analysis. These determinations were based upon a qualitative knowledge of SEM-EDX elemental interference problems and a quantitative determination of the significance of elemental concentrations relative to their reported values and uncertainties.

2. Elements that were clearly not distinctive to one source or factor. This determination was made based on the criteria that any element which had a factor loading greater than ± 0.4 for three or more factors was not indicative of any one source.

3. Elements that are known to be a distinctive tracer for more than one source and were, therefore, adding confusion and uncertainty to the analysis.

4. Elements that were not significantly contributing any further information in identifying a source.

This process, combined with the usually sound PCA techniques, helped to ensure an accurate and reliable interpretation of the sources of regional background particulate matter in Alberta. The major drawback to this type of process is that the results may be less specific than they would be if all of the elemental data were to be used. The identification of a factor as a source category (i.e. crustal material) as opposed to a more specific source type (i.e. construction, road dust, agricultural soil)

must be balanced with the knowledge that the results are much more precise and trustworthy.

4.4.3 Protocols

1. Mass concentrations ($\mu g/m^3$) for the PM_{10} filter sampling periods were determined by using the mass concentrations recorded by the TEOM during the same time period and duration as the MiniVol PM_{10} collection.

2. The resulting mass concentrations ($\mu g/m^3$) were multiplied by the average elemental abundances (%) determined by the SEM-EDX for the same time periods resulting in average elemental mass concentrations (ng/m^3).

3. The average elemental mass concentrations (ng/m^3) for each filter sample were converted into z-scores.

4. The z-score data matrix was then subjected to the principle component analysis (PCA) utilizing SYSTAT Version 9.0® using a Varimax rotation (SPSS, 2000).

5. Elements were eliminated and the PCA was repeated until all conditions described in Section 4.3.2 Receptor Models for Regional Background Studies were met.

6. The results of the PCA were compared to previous studies, relevant literature, and particulate matter databases (including the U.S. Environmental Protection Agency's SPECIATE database (U.S. EPA, 1993)) to identify and categorize the most likely sources of PM_{10} at the receptor location.

4.5 Quality Control and Quality Assessment

The two aspects of quality assurance, quality control and quality assessment, must be applied in a study of this kind to ensure that sampling, analysis and data handling procedures produce high data quality. Parameters that indicate data quality include: precision, accuracy, representativeness, completeness and comparability. The errors in sampling, analysis and data handling that often reduce data quality can be ascribed to the following: misinterpretation of sampling plans, incorrect implementation of sampling plans with approved or validated protocols, disregard for or misunderstanding of the importance of adhering to sampling procedures, equipment calibration errors, contamination, sample storage and transportation errors, and sample documentation errors (Taylor, 1996). Many of these errors can be minimized by carefully implementing well-designed and detailed quality control and quality assessment plans.

Quality control helps to ensure high data quality through the application of good measurement practices, good laboratory practices and standard operations procedures specially designed for sampling. The sampling, laboratory and receptor modeling processes should be based on protocols specially developed for the specific analytical problem. Strict adherence to these protocols is essential and sampling personnel should be trained to follow the protocols faithfully. All required calibrations must be made on the basis of established schedules and performed according to required procedures. Special care must be devoted to not contaminate sample containers and to stabilization and protection of samples during

transportation and storage. A system for assuring positive identification of samples and documentation of all sample details must be in place.

Quality assessment of the sampling process depends largely on monitoring for adherence to the respective protocols. An audit system performed on a continuing basis is the best means to accomplish this purpose. A system that uses replicates, field blanks and control blanks should be part of a sampling and analysis protocol. A replicate is two or more samples representing the same population, time and place, which are independently carried through all the steps of the sampling and measurement process in an identical manner. Control blanks are clean samples processed to measure artifacts in the measurement process. Field blanks are clean samples carried to the sampling site and exposed to the sampling locations. These types of measurements can help to deduce the data quality by indicating the amount of sample contamination. Sample contamination may arise from a myriad of sources. These include: sample collection, sample transportation and storage, sample preparation and sample analysis.

To ensure that proper quality control and quality assurance standards in the present study were met, actions were taken prior to and during fieldwork, laboratory analysis and data handling. Comprehensive protocols were developed for the operation of the TEOM, MiniVol and SEM-EDX and for the execution of the receptor model. Prior to fieldwork commencing, a full review of measurements methods, laboratory analysis methods, and receptor modeling procedures was done to ensure appropriate compliance would be met with appropriate standards. In addition, with full knowledge of the capabilities of the sampling equipment, the

110

equipment was disassembled and calibrated according to the manufacturer's requirements to ensure operational success during sampling. For a contingency, main spare parts for the TEOM and MiniVol samplers were obtained and brought into the field during each sampling period. Throughout and in-between the seasonal sampling periods the equipment was checked for optimal operational success. Before each seasonal sampling period began, the equipment was assembled and tested for approximately 48 hours to ensure that complications had not arisen since the equipment was last used. The project coordinator was solely responsible for the equipment at the site for each sampling period to ensure standard operating procedures were consistently followed.

A full sampling plan involving the TEOM and MiniVol samplers was developed prior to the first sampling season. The appropriate filter number (including blanks and replicates) was marked based on the sampling plan prior to leaving the laboratory. Detailed field notes were taken for each sampling day and recorded in an Air Sampling Field Log form (Appendix 8.1), noting such things as operational status, sampling durations, and weather conditions. Potential sources of particulate matter such as forests fires or construction activity were also noted. Complete plans and protocols were also developed prior to laboratory and data analysis. These protocols ensured that representative and random data was obtained in such a manner as to reduce bias as much as possible. All noteworthy observations during SEM-EDX analysis were recorded in a SEM-EDX PM_{10} Analysis Data Log form (Appendix 8.1). These included: the sample number, sample type, number of particles analyzed, a description of each particle analyzed, and other relevant

observations. All protocols for sampling, laboratory and data handling were strictly and consistently adhered to.

To ensure proper quality assessment, replicates, control blanks and field blanks were routinely taken in the field and analyzed along with the sample filters. All replicates were taken by co-locating a second MiniVol with the first and subjecting the filter to the same sampling conditions, time and place as the actual samples. Control blanks were taken at the beginning of each sampling season and were stored until required for analysis in order to measure artifacts in the measurement process. Field blanks were carried to the sampling site and exposed to the sampling conditions and were then subsequently stored until required for analysis. All replicates, control blanks and field blanks were analyzed by the SEM-EDX in the identical manner as the samples. The information provided by these measurements was used to help deduce the quality of the data by indicating the amount of sample contamination and reproducibility.

CHAPTER 5: RESULTS AND DISCUSSION

5.1   Particulate Matter Level Results

5.1.1   Levels

Continuous ambient air monitoring was performed using a TEOM to measure regional background PM_{10} concentrations at a representative location in Devon, Alberta for the periods of August 1 through August 23 and October 3 through October 25 of 2000. A total of twenty-two consecutive days for each month were monitored for a total of forty-four monitoring days. The monitoring adhered to the techniques and protocols outlined in Section 4.1 Particulate Matter Sampling. Comprehensive data was collected by the TEOM for mass concentration, 30-minute average concentration, 1-hour average concentration, 24-hour average concentration, total mass, temperature and atmospheric pressure for both the August and October monitoring periods. These data are presented in detail in Appendix 8.2 TEOM Raw Data. The results for the PM_{10} 1-hour average concentrations for August 1 through August 23, 2000 are presented in Figure 11. The results for the PM_{10} 1-hour average concentrations for October 3 through October 25, 2000 are presented in Figure 12. The results for the PM_{10} 24-hour average concentrations for August 1 through August 23, 2000 are presented in Figure 13. Finally, the results for the PM_{10} 24-hour average concentrations for October 3 through October 25, 2000 are presented in Figure 14.
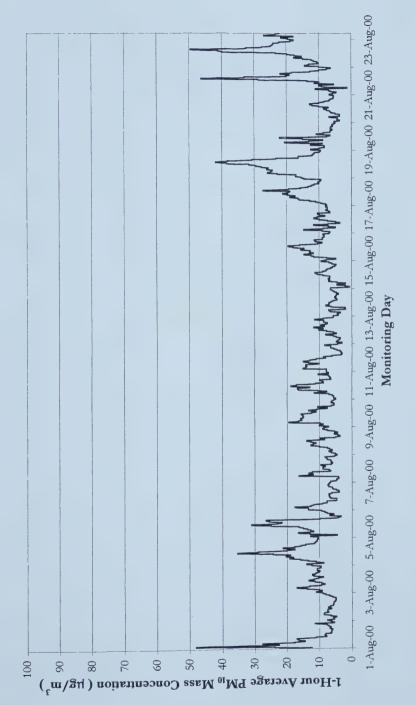
Figure 11. TEOM 1-Hour Average PM$_{10}$ Mass Concentration Air Sampling Results for Devon, Alberta for August 1, 2000 to August 23, 2000.
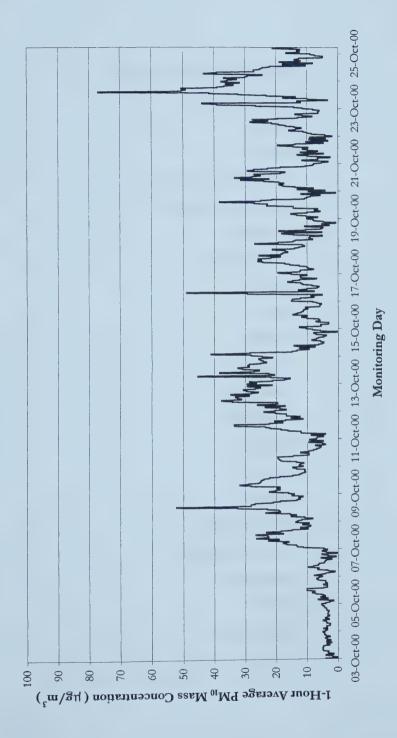
Figure 12. TEOM 1-Hour Average PM$_{10}$ Mass Concentration Air Sampling Results for Devon, Alberta for October 3, 2000 to October 25, 2000.
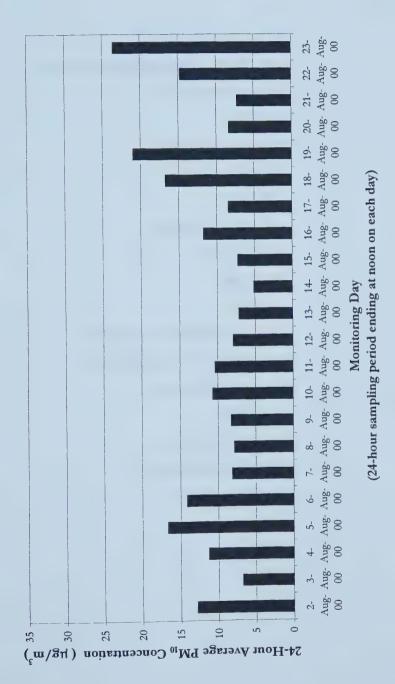
Figure 13. TEOM 24-Hour Average PM$_{10}$ Mass Concentration Air Sampling Results for Devon, Alberta for August 2, 2000 to August 23, 2000.
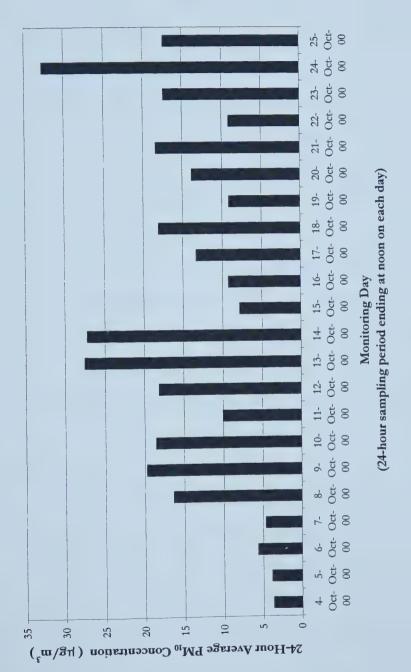
Figure 14. TEOM 24-Hour Average PM$_{10}$ Mass Concentration Air Sampling Results for Devon, Alberta for October 4, 2000 to October 25, 2000.

117

It was observed that 1-hour average PM_{10} levels were very low (i.e. <20 $\mu g/m^3$) for most of both sampling seasons (Figures 11 and 12). However, a number of peaks did occur on several occasions and there were times of sustained elevated levels (especially during the October sampling season). Depending on local meteorological conditions, short-term fluctuations in PM_{10} levels at a fixed location (such as the monitoring site in Devon) can generally be attributed to near-field sources and/or atmospheric transport from sources further away under prevailing winds. For instance, the elevated levels observed during the periods of August 18 to August 23, October 11 to October 14, and October 23 to October 25 could most likely be attributed to near-field sources. Roadwork, construction and lawn maintenance all occurred during these time frames in very close proximity (i.e. <100 m) to the receptor location. Whereas on August 1, August 4, October 8, and October 16, elevated levels of PM_{10} were due mainly to regional emissions from distant forest fires and prescribed agricultural burning events that were carried to the area by the prevailing winds. All observations and events were recorded in field notes during sampling.

Prolonged durations of low 1-hour average PM_{10} levels can more than likely be explained by the influences from precipitation events and snow cover, which work to scavenge particles from the atmosphere and to inhibit the re-suspension of particulate material. For example, the low levels observed in the middle of August (i.e. August 11 to August 14) are due mainly to the large amount of precipitation that was detected during this time (Environment Canada, 2000). The low levels of PM_{10}

observed for early October (i.e. October 3 to October 7) are explained mainly by the snow cover present during that time (Environment Canada, 2000).

The 1-hour average PM_{10} levels exhibited a cyclical trend characteristic of the daily trends of outdoor pollutants, increasing in concentration during the day and decreasing at night. The lowest levels were often observed during the very early hours of the morning when the least amount of human activity was occurring. The highest levels were observed between the hours of 5:00 am in the morning and midnight when a greater amount of human activity was occurring. In addition to diurnal patterns, weekly patterns were also observed. In this case, levels were found to be higher during the weekdays and lower on the weekends. This is again a result of the greatest amount of human activity occurring during the weekdays.

It was observed that 24-hour average PM_{10} levels were very low (i.e. <20 $\mu g/m^3$) for most of both sampling seasons (Figures 13 and 14). However, average daily levels over 20 $\mu g/m^3$ were observed on a number of occasions including: August 19, August 23, October 13, October 14 and October 24. In each of these instances, the elevated levels can be attributed to the influences of near-field activities. Roadwork, construction and lawn maintenance were all observed during these days in very close proximity (i.e. <100 m) to the receptor location. Those average daily levels that were very low (i.e. <10 $\mu g/m^3$) are due mainly to the affects of precipitation and snow cover. Substantial amounts of precipitation was observed during the time periods of August 12 to August 15 and October 15 to October 16,

and the time period of October 4 to October 7 was dominated by snow cover (Environment Canada, 2000).

Table 9 describes the relevant descriptive statistics for the 1-hour average PM_{10} mass concentration data for the entire sampling period. The mean 1-hour average concentration for the August sampling period was 11 $\mu g/m^3$ and the standard deviation was 7.2 $\mu g/m^3$. The mean 1-hour average concentration for the October sampling period was 15 $\mu g/m^3$ and the standard deviation was 10 $\mu g/m^3$. The mean 1-hour average concentration for the entire sampling period (i.e. August and October) was 13 $\mu g/m^3$ and the standard deviation was 8.8 $\mu g/m^3$. The maximum 1-hour average concentration over the entire sampling period was 77 $\mu g/m^3$, which occurred on October 23 at 9:00 p.m., and the minimum 1-hour average concentration over the entire sampling period was 2.0 $\mu g/m^3$ (method detection limit for the TEOM), which occurred on numerous occasions.

Table 9. 1-Hour Average PM_{10} Concentration Statistics Summary.

Sampling Period	Mean	Standard Deviation	Maximum	Minimum
August	11 $\mu g/m^3$	7.2 $\mu g/m^3$	50 $\mu g/m^3$	*2.0 $\mu g/m^3$
October	15 $\mu g/m^3$	10 $\mu g/m^3$	77 $\mu g/m^3$	*2.0 $\mu g/m^3$
Total	13 $\mu g/m^3$	8.8 $\mu g/m^3$	77 $\mu g/m^3$	*2.0 $\mu g/m^3$

(* TEOM method detection limit)

Table 10 describes the relevant descriptive statistics for the 24-hour average PM_{10} mass concentration data for the entire sampling period. The mean 24-hour average concentration for the August sampling period was 11 $\mu g/m^3$ and the standard deviation was 4.9 $\mu g/m^3$. The mean 24-hour average concentration for the October sampling period was 15 $\mu g/m^3$ and the standard deviation was 8.0 $\mu g/m^3$. The mean 24-hour average concentration for the entire sampling period (i.e. August and October) was 13 $\mu g/m^3$ and the standard deviation was 6.4 $\mu g/m^3$. The maximum 24-hour average concentration over the entire sampling period was 33 $\mu g/m^3$, which occurred on October 24, and the minimum 24-hour average concentration over the entire sampling period was 3.6 $\mu g/m^3$, which occurred on October 4.

Table 10. 24-Hour Average PM_{10} Concentration Statistics Summary.

Sampling Period	Mean	Standard Deviation	Maximum	Minimum
August	11 $\mu g/m^3$	4.9 $\mu g/m^3$	24 $\mu g/m^3$	5.1 $\mu g/m^3$
October	15 $\mu g/m^3$	8.0 $\mu g/m^3$	33 $\mu g/m^3$	3.6 $\mu g/m^3$
Total	13 $\mu g/m^3$	6.4 $\mu g/m^3$	33 $\mu g/m^3$	3.6 $\mu g/m^3$

5.1.2 Seasonal Variation

The August and October sampling seasons were compared to determine whether the 24-hour average PM_{10} concentrations exhibited seasonal variation (Figure 15). The results indicate that there was a discernable seasonal difference between the concentrations. The mean 24-hour average concentration for the August sampling season was 11 $\mu g/m^3$ and the standard deviation was 4.9 $\mu g/m^3$. The mean 24-hour average concentration for the October sampling period was 15 $\mu g/m^3$ and the standard deviation was 8.0 $\mu g/m^3$. The mean 24-hour average concentration for the October sampling season was 31% greater than the mean 24-hour average concentration for the August sampling season. In addition, the standard deviation for the October sampling season was much higher (i.e. 63%) than the standard deviation for the August sampling season.

The difference in the mean 24-hour average concentrations of the two sampling seasons was most likely a result of seasonal meteorological variations and differences in near-field emission types and quantities. The meteorological variable with the greatest influence was precipitation. The general effect of precipitation is the scavenging of particulates and gases from the atmosphere and the reduction in the amount of particle re-suspension. The total precipitation for the month of August was 32.4 mm and the total precipitation for month of October was 4.0 mm (Environment Canada, 2000). It is evident that the considerable amount of precipitation in August contributed significantly to lower levels observed. It was also observed that more near-field emission sources were present at the receptor location

in October when compared to August. These sources included such things as construction, roadwork, lawn maintenance and residential wood burning. While these activities did occur in August as well as October, their frequency and duration was observed to be much larger in October.

The differences in the standard deviations of the two sampling seasons are most likely a result of a greater amount of variability in seasonal meteorological conditions and near-field emission types and quantities. Meteorological conditions such as temperature, wind speed and precipitation were much more erratic during the October sampling season when compared to the August sampling season. In October, average daily temperatures ranged from −10.0°C to 22.6°C, average daily wind speed ranged from 5 km/h to 26 km/h, and precipitation occurred only sporadically (Environment Canada, 2000). In August, average daily temperatures ranged from 2.3°C to 27.1°C, average daily wind speed ranged from 4 km/h to 22 km/h, and precipitation occurred more consistently (Environment Canada, 2000). In addition, the near-field activities observed at the receptor location occurred more intensely and intermittently in October when compared to August.
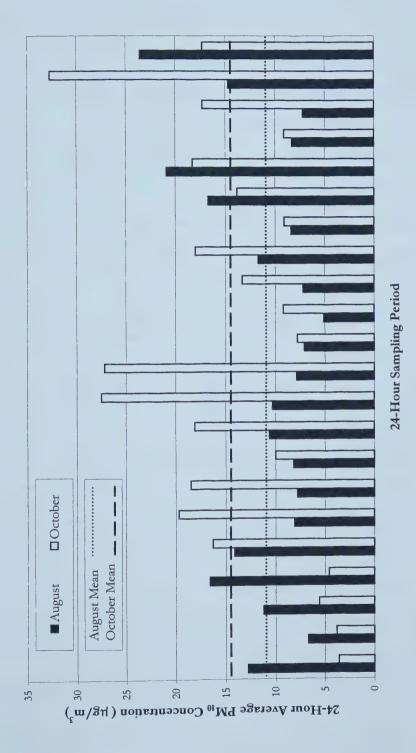
Figure 15. Comparison of the TEOM 24-Hour Average PM$_{10}$ Mass Concentration Air Sampling Results for the August and October Sampling Seasons.

124

5.1.3 Meteorological Influences

Atmospheric phenomena play an important role in the determination of ambient air quality. Diurnal and seasonal fluctuations in source emissions tend to be reflected in ambient particulate matter levels, but the diurnal and seasonal variations in meteorological conditions superimpose an effect on those due to emission variations. Clearly, the objectives of a monitoring program will not be attained if due consideration is not given to meteorological information. Meteorological parameters have varying degrees of influence on ambient air quality. The parameters of major importance are wind speed, wind direction, precipitation and temperature. Other influences may be attributed to atmospheric stability, humidity and solar radiation.

Wind speed and direction will directly effect the movement and dispersion of particulate matter from emission sources within a given study area. Ambient levels have been found to be inversely related to wind speed (Colls, 1997). The types of emission sources and the impact that they have on a receptor are directly controlled by the prevailing wind direction. Precipitation can take the form of rain, sleet, snow, hail and various combinations thereof. The general effect of precipitation is the scavenging of particulates and gases from the atmosphere. The net result of precipitation may be the removal of particles from the atmosphere before dispersion can take place. In such cases, a high concentration of particulate matter might be measured during the initial stages of the rainfall event. Low temperatures can result in decreased suspended particulate matter concentrations due to a restriction of secondary particulate formation.

Meteorological data were taken from the local meteorological conditions for the Edmonton International Airport located approximately 20 km east of Devon (Appendix 8.3 Meteorological Data) (Environment Canada, 2000) and used in conjunction with the TEOM mass concentration data (Appendix 8.2 Raw TEOM Data) to illustrate the influences of meteorology on the PM_{10} concentrations in this study. The effect of wind direction is demonstrated in Figures 16 and 17. In Figure 16, the maximum 1-hour average PM_{10} mass concentration occurrences for the August sampling season are compared to wind direction. Maximum mass concentration occurrences are those concentrations that are greater than the average mass concentration plus one standard deviation. Thus, a mass concentration was considered maximum if it was greater than 11 $\mu g/m^3$ plus 7 $\mu g/m^3$ (18 $\mu g/m^3$). The results indicate that the bulk of the maximum mass concentration occurrences of PM_{10} detected at the receptor location (about 22%) were originating from the south. This percentage held true even though the prevailing wind direction during this sampling season was from the west and west-northwest. The rest of the maximum occurrences were originating slightly from all other directions (mostly from the southeast). This result suggests that the PM_{10} detected at the receptor location during the August sampling season was predominantly originating from sources in the south and southeast. The only known large sources in these directions were open agricultural fields and the Edmonton International Airport. Another possible explanation is that the high concentrations originating from the south occurred due mainly to the near-field activities at the receptor location. These activities included such things as lawn mowing, local construction and residential wood burning.

126
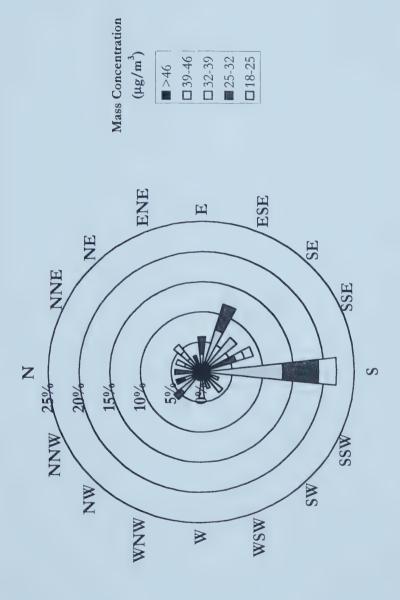
Figure 16. Wind Rose for the Maximum 1-Hour Average PM$_{10}$ Mass Concentration Occurrences for the August Sampling Season.
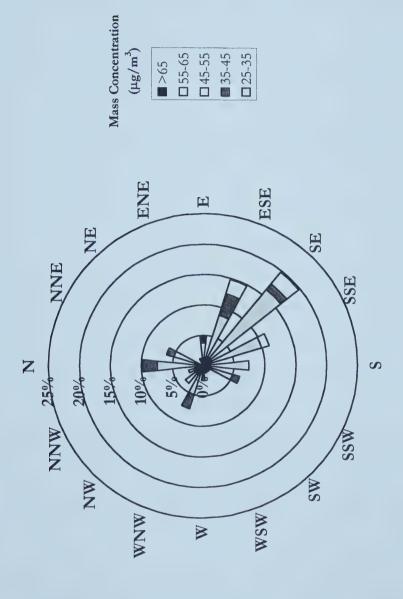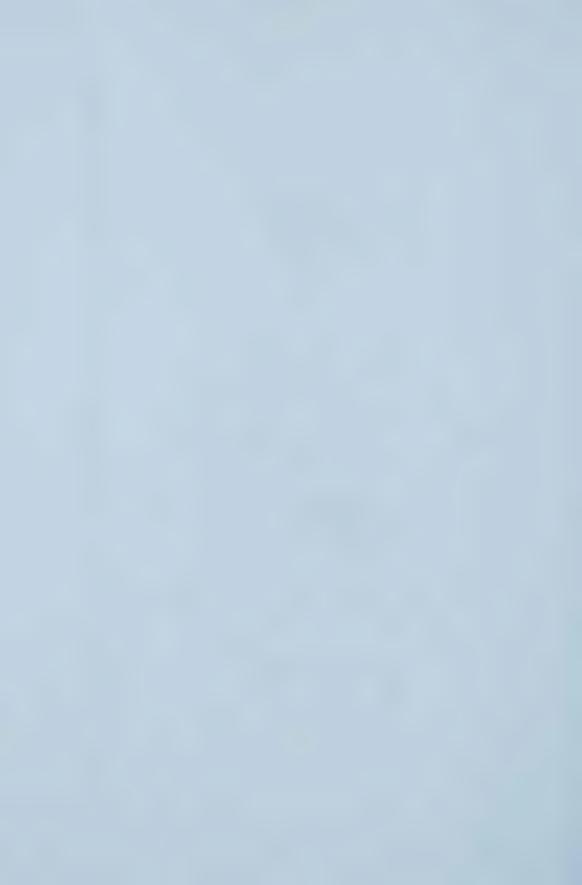
Figure 17. Wind Rose for the Maximum 1-Hour Average PM$_{10}$ Mass Concentration Occurrences for the October Sampling Season.

In Figure 17, the maximum 1-hour average PM_{10} mass concentration occurrences for the October sampling season are compared to wind direction. In this case, a mass concentration was considered maximum if it was greater than the average (15 $\mu g/m^3$) plus one standard deviation (8 $\mu g/m^3$) or 23 $\mu g/m^3$. The results indicate that almost half of the maximum mass concentration occurrences of PM_{10} detected at the receptor location (about 46%) were originating generally from the southeast even though the prevailing wind direction during this sampling season was from the south. The rest were originating more or less equally (i.e. under 10%) from the other directions. In addition, each very high concentration occurrence (i.e. >45 $\mu g/m^3$) originated in the southeast. This suggests that the PM_{10} detected at the receptor location was predominantly originating from sources in the southeast. Similar to the August sampling season, the only known large sources in this direction were open agricultural fields and the Edmonton International Airport; and as before, the high concentrations could also likely be explained by similar near-field activities.

The effects of other meteorological phenomenon are demonstrated in Figures 18 and 19. In Figure 18, the 24-hour PM_{10} average mass concentrations for the August sampling season are compared to average daily temperature, wind speed and precipitation. Even though the temperature at the receptor location did not fall below 10°C during this sampling season, the values for concentration and temperature did follow a similar pattern. Generally, when the temperature was high (i.e. August 5), so was the concentration. The opposite affect can also be seen. When the temperature was low (i.e. August 14), so was the concentration. An explanation
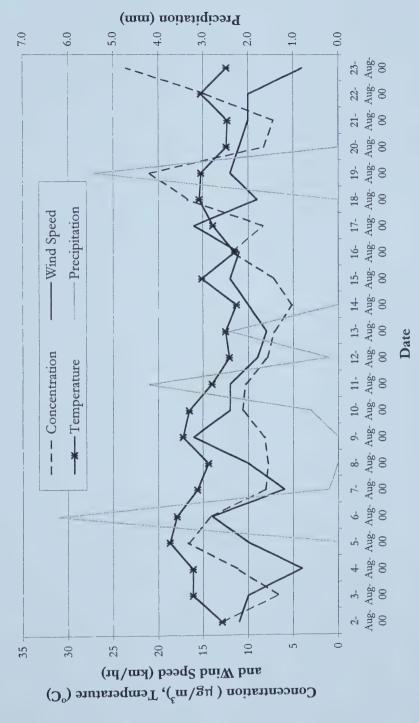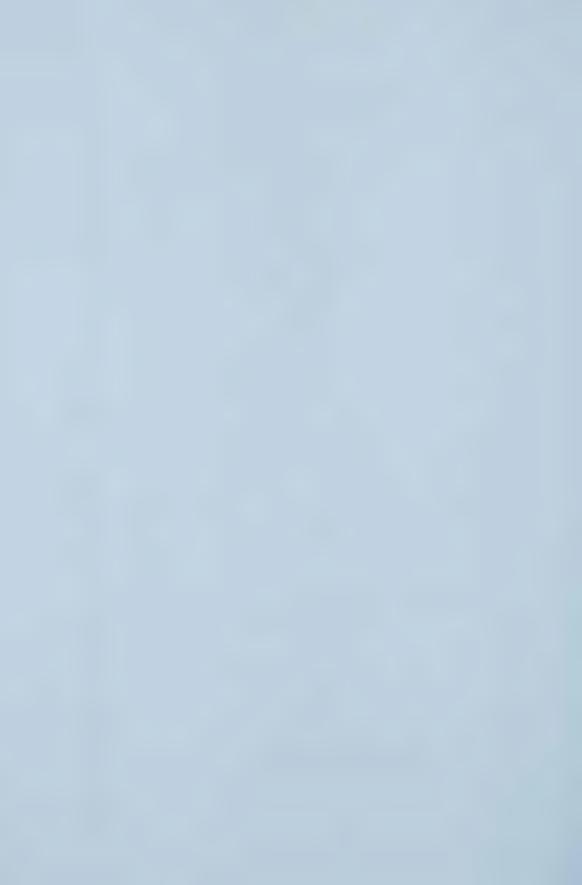
Figure 18. Comparison of the 24-Hour Average PM$_{10}$ Mass Concentration to Temperature, Wind Speed and Precipitation for the August Sampling Season.

130
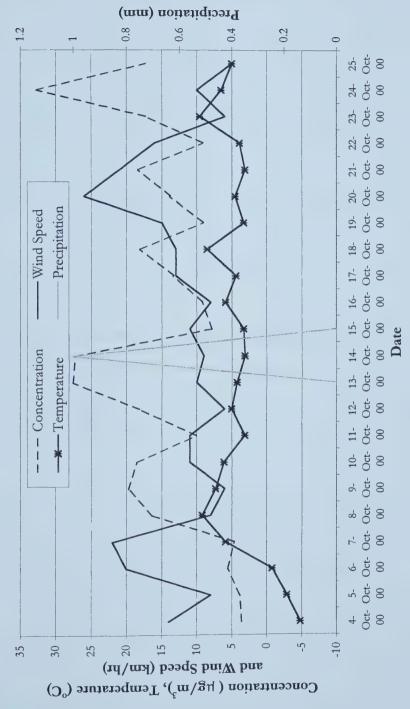
Figure 19. Comparison of the 24-Hour Average PM$_{10}$ Mass Concentration to Temperature, Wind Speed and Precipitation for the October Sampling Season.

131

for this pattern may be that low temperatures resulted in decreased particulate matter concentrations due to the restriction of secondary particulate formation.

The effect of wind speed during the August sampling season can also be seen in Figure 18. The results indicate that when the wind speed was clam (i.e. <5 km/h) the PM_{10} concentration was high; and when the wind speed was higher (i.e. >5 km/h), the concentration was low. For example, on August 23, the average wind speed was 4 km/h and the 24-hour average concentration was almost 25 $\mu g/m^3$. However, on August 9, the average wind speed was 16 km/h and the 24-hour average concentration was about 8 $\mu g/m^3$. It was concluded that sources contributing to peak PM_{10} levels observed were more likely close to the monitor (i.e. near-field) because the low wind speeds would be insufficient to transport pollutants from further away and would not be capable to aid in particle dispersion. For instance, on August 23 there was a substantial amount of construction occurring approximately 100 m from the receptor location, and since the wind speed was not sufficient to aid in dispersion of the emissions, the PM_{10} concentration was high. On the other hand, on August 9 there were no known near-field sources or activities, wind speed was high, and the concentration was low. It can therefore be assumed that particulate matter measured for that day was largely due to regional sources.

Finally, the effect of precipitation during the August sampling season can be seen in Figure 18. The figure clearly illustrates that the concentration fell considerably immediately after a precipitation event (i.e. August 6 and 19). In addition, when there was a prolonged precipitation event (i.e. August 10th to 13th), the

concentration continually declined until the event had concluded, at which time it increased. The general reason for this affect was that the precipitation scavenged the particulates and gases from the atmosphere. Additionally, particles that were compacted and were under the cover of water could not be easily re-suspended into the air by natural (wind) or mechanical (i.e. movement of vehicles or machinery) means.

In Figure 19, the 24-hour average PM_{10} mass concentrations for the October sampling season are compared to average daily temperature, wind speed and precipitation. The effect of temperature on the particulate matter levels during the October sampling season was similar to that seen in the August sampling season. When the temperature was below 0°C (i.e. October 4th to 6th) the concentration was very low (i.e. <5 $\mu g/m^3$). As the temperatures increased, so did the concentration. Again, an explanation for this pattern may be that low temperatures resulted in decreased particulate matter concentrations due to the restriction of secondary particulate formation. Another reason may be that lower temperatures resulted in less outdoor human activities that could have contributed to particulate matter levels.

The effect of wind speed during the October sampling season can also be seen in Figure 19. As with the August sampling season, the results suggest that when the wind speed was clam (in this instance <10 km/h because the average daily wind speed for this month did not drop below 5 km/h) the PM_{10} concentration was high, and when the wind speed was high (i.e. >10 km/h) the concentration was low. For example, on October 24, the wind speed was nearly 10 km/h and the concentration

was almost 35 $\mu g/m^3$. However, on October 7, the wind speed was about 22 km/h and the concentration was roughly 5 $\mu g/m^3$. Similar to August, it was concluded that the sources contributing to peak PM_{10} levels observed were more likely close to the monitor (i.e. near-field) because the low wind speeds would be insufficient to transport pollutants from further away and would not be able to aid in particle dispersion. For instance, on October 13 there was a substantial amount of roadwork occurring approximately 100 m from the receptor location, and since the wind speed was not sufficient to aid in the dispersion of the emissions, the PM_{10} concentration was high. On the other hand, on October 7, there were no known near-field sources or activities, the wind speed was high, and the concentration was low. It can therefore be assumed that the particulate matter measured for that day was most likely due largely to regional sources.

Finally, the affect of precipitation during the October sampling season can be seen in Figure 19. The figure clearly shows that the concentrations fell considerably immediately after the only precipitation event (October 14).

The fact that there was substantially less precipitation during the October sampling season compared to the August sampling season could help explain the higher PM_{10} concentrations measured in October.

5.1.4   Comparison of Results to Similar Studies and Regulations

In Table 11 results of the present study are compared with those of similar studies conducted in Alberta and some current regulations. A number of observations can be made. In comparison to other regional background studies, the results of this study are very analogous. The mean 24-hour PM_{10} average mass concentration measured at monitoring heights of 3 to 4 m in other regional background sites throughout Alberta was reported to be 17 $\mu g/m^3$ (Cheng et al., 2000) compared to 13 $\mu g/m^3$ for Devon at a monitoring height of 1.9 m. This comparability suggests that the emission sources and quantities in Devon are similar to those found in other regional background sites in Alberta and that monitoring height does not seem to be a strong influencing factor. A comparison of the results with those of rural remote studies (8.8 $\mu g/m^3$ (Cheng et al., 2000)) indicates that non-point anthropogenic sources (i.e. vehicles, road dust, agriculture, construction) have a significant influence on the PM_{10} concentrations in Devon. As expected, the results from the present study are lower than those of rural industrial sites (i.e. rural areas with near-field industrial activates). Measured rural industrial concentrations of approximately 25 $\mu g/m^3$ (McCullum and Kindzierski, 2000) imply that near-field industrial activities can have a substantial influence on local ambient PM_{10} levels. The results of Alberta urban studies (29 $\mu g/m^3$ for Edmonton and 26 $\mu g/m^3$ for Calgary (Alberta Environment, 1996)) demonstrate much higher ambient levels of PM_{10} than those measured in Devon, which indicates urban activities can have a large impact on

local PM_{10} levels. Finally, at no time were the 24-hour average concentrations measured in Devon during the two sampling seasons in violation of any relevant current regulations of selected jurisdictions.

Table 11. Comparison of Mean 24-Hour PM_{10} Concentrations to Other Various Locations and Regulations

Site Type	Location/Source	Mean 24-Hour PM_{10} Concentration
Regional Background	Devon, Alberta – August (present study)	$11 \ \mu g/m^3$
Regional Background	Devon, Alberta – October (present study)	$15 \ \mu g/m^3$
Regional Background	Devon, Alberta – Total (present study)	$13 \ \mu g/m^3$
Regional Background	Numerous Alberta Locations (Cheng et al., 2000)	$17 \ \mu g/m^3$
Rural Remote	Numerous Alberta Locations (Cheng et al., 2000)	$8.8 \ \mu g/m^3$
Rural Industrial	High Level, Alberta (McCullum and Kindzierski, 2000)	$25 \ \mu g/m^3$
Urban	Edmonton, Alberta (Alberta Environment, 1996)	$29 \ \mu g/m^3$
Urban	Calgary, Alberta (Alberta Environment, 1996)	$26 \ \mu g/m^3$
Regulation	U.S. Environmental Protection Agency (U.S. EPA, 1997)	$150 \ \mu g/m^3$
Regulation	World Health Organization (Pryor and Barthelmine, 1996)	$70 \ \mu g/m^3$
Regulation	California, USA (Pryor and Barthelmine, 1996)	$50 \ \mu g/m^3$
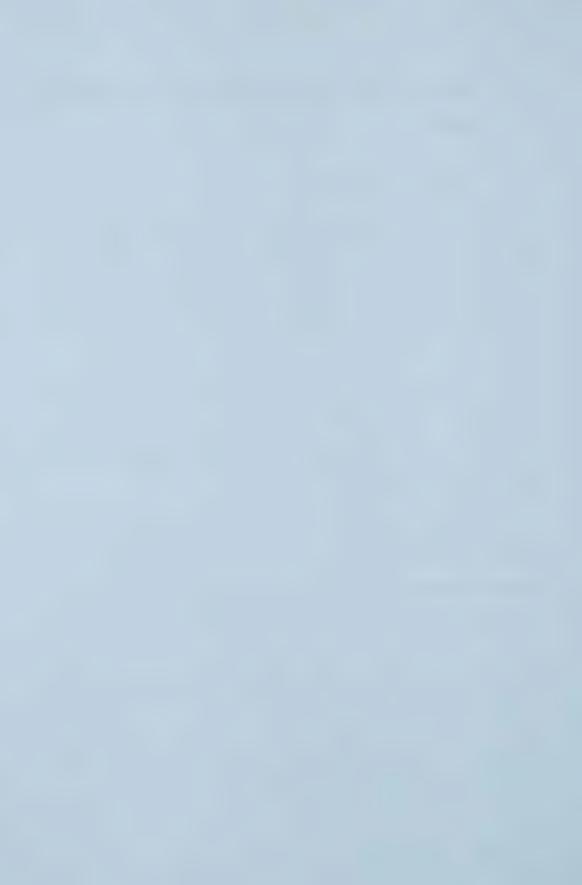
5.2   Particulate Matter Chemical Composition and Morphology Results

5.2.1   Chemical Composition

Ambient air sampling was conducted using the MiniVol to obtain regional background PM_{10} filter samples. A total of forty-four samples, in addition to blanks and replicates, were collected and subsequently analyzed by means of the SEM-EDX for a total of nineteen elements (Si, Ca, Fe, Al, K, Na, Mg, Mn, Cl, S, P, Ti, V, Pb, Cr, Ni, Cu, Zn and As) and their biological material content. These elements were chosen for analysis because of their suspected abundances, strong tracer characteristics, and a qualitative knowledge of possible SEM-EDX elemental interference problems (Braybrook, 2001). The SEM-EDX analysis adhered to the techniques and protocols outlined in Section 4.3 Laboratory Analysis.

Complete data for sample descriptions, elemental compositions (%) and elemental concentrations (ng/m^3) for the August and October sampling periods are presented in detail in Appendix 8.4 Raw Chemical Composition Data. The results of the SEM-EDX analysis for the total PM_{10} elemental composition and biological material content for August 1 through August 23, 2000 and October 3 through October 25, 2000 as a whole are presented in Figure 20. The elemental composition is presented as a percent relative abundance of the total composition and the biological material content is presented as a ratio between the number of biological particles counted per ten particles elementally analyzed.
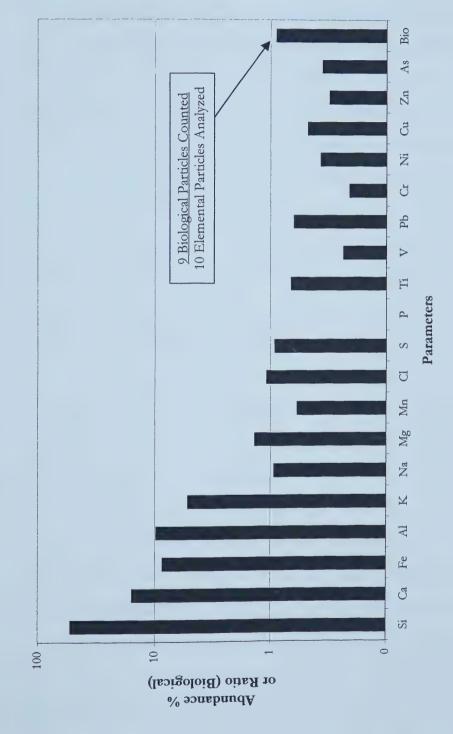
Figure 20. Results of the SEM-EDX PM$_{10}$ Elemental Analysis for the Entire Sampling Period.

The results of the SEM-EDX analysis illustrate a distinct difference between those elements that were found to be highly abundant (i.e. >1%) and those that were found only in trace amounts (i.e. <1%). The elements that were highly abundant contributed the vast majority (93%) to the total composition of the PM_{10} samples and included: Si, Ca, Fe, Al, K and Mg. These elements tend to be associated with crustal or lithophilic sources such as agricultural activities, undisturbed soil, paved roads, unpaved roads, construction and others (Beceiro-Gonzalez et al., 1997). They can, however, also indicate the presence of particles originating from coal combustion (Chow, 1995). An additional abundant element, Cl, is usually associated with combustion and incineration activities and salt aerosols (Marcazzan, 1998; U.S. EPA, 1993). Those elements that were present in trace amounts included: Na, Mn, S, P, Ti, V, Pb, Cr, Ni, Cu, Zn and As. The majority of these trace elements are heavy metals that are indicative of industrial and other anthropogenic activities (Chow, 1995). The other trace elements such as V and S are indicative of oil combustion and regional sulphates (Tuncel et al., 1985; Marcazzan, 1998). The amount of biological material (measured as a ratio), including organic and elemental particles, was just below one (i.e. approximately 9 biological particles counted for every 10 elemental particles analyzed). This value indicates that approximately an equal amount of particles of biological origin were present in the atmosphere at the sampling location as inorganic particles during the sampling periods. This result is not surprising since biological material has been consistently shown to make-up a large proportion of the PM_{10} found in ambient air (Hopke, 1985).

5.2.2   Morphology

By supplementing the quantitative EDX analysis with qualitative information obtained through use of the SEM, additional observations can be made about each of the particles analyzed and their possible sources. Specifically, information about morphology (size and shape) of each particle analyzed can be determined microscopically using SEM. This information can then be used in combination with elemental spectra determined by the EDX analysis in order to categorize PM_{10} sampled at the receptor location in Devon. Many different categories of particles can be fashioned in this way and additional information about sources can be obtained. These particle categories can, in turn, provide information which quantitative chemical analysis alone cannot. In particular, any emission source that has particles similar in elemental characteristics to another can be revealed because of different particle morphological characteristics. Examples of this include the ability to distinguish between flyash originating from coal combustion and mineral material originating from crustal origins, and between organic (i.e. pollen) and elemental (i.e. ash) biological material.

The criteria shown in Table 12 were used to classify each particle analyzed by the SEM-EDX into the following categories: silica crystal, mineral (clay), coal flyash, biological – organic, biological – elemental, combustion, oil, salt and other (Dzubay and Mamane, 1989). In general, every particle randomly selected on the sample filters was classified into one of these categories based on their morphologies and their EDX elemental spectral peaks. It should be noted, however, that a number of

particles were viewed during the SEM analysis that could not be analyzed by means of the EDX because they were too small in size. The EDX can typically only analyze particles >0.2 µm in diameter (Henry, 1985). At times, these particles contributed substantially to the total number of visible particles on a given filter. Examples of these small particles are oil droplets (Figure 21). These particles were present at much greater quantities than what is indicated in Table 12, but some of them (i.e. those <0.2 µm in size) could not be analyzed or accounted for because of size constraints.
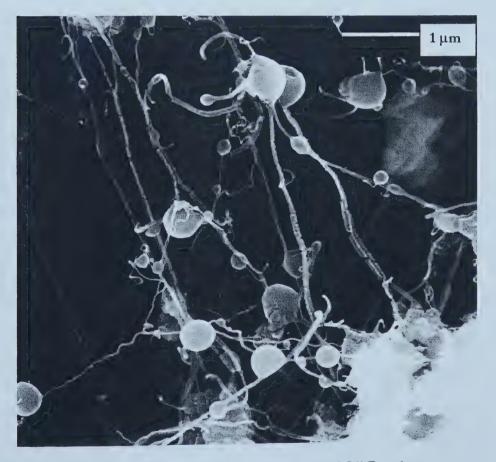
Figure 21. SEM Photograph of a Cluster of Oil Droplets.

Table 12. Criteria for Classifying Particles into Categories (Dzubay and Mamane, 1989).

Category	Morphology	Major Spectral Peaks
Silica Crystal	Non-spherical and large.	High peak for Si only.
Mineral (Clay)	Non-spherical and large.	High peaks for Si and/or Ca and variable amounts of Al, K, Ti and Fe.
Coal Flyash	Small, smooth and spherical.	Same as mineral.
Biological - Organic	Characteristic of spores or pollen.	High peak for background Au only.
Biological - Elemental	Non-specific.	High peak for background Au only.
Combustion	Non-specific.	Same as mineral with additional peaks for Cl and Zn.
Oil	Small, smooth and spherical.	High peak for S only.
Salt	Non-specific.	Mainly Cl with detectable Na.
Other	Non-specific.	Non-specific.

To illustrate use of the above criteria and to present specimens of each category, the following figures depict SEM photographs of each category and corresponding EDX elemental spectral graph of the particle. Specimen particles selected were of similar size so that they could be easily compared. All peaks on the

EDX elemental spectral graphs labeled as Au are a result of background concentrations of gold from the coating procedure. Specifically:

- Figure 22 illustrates a SEM photograph of a typical silica crystal particle (non-spherical and large) and Figure 23 is its corresponding EDX elemental spectral graph depicting a peak for Si only.

- Figure 24 illustrates a SEM photograph of a typical mineral (clay) particle (non-spherical and large) and Figure 25 is its corresponding EDX elemental spectral graph depicting high peaks for Si and/or Ca and variable amounts of Al, K, Ti and Fe.

- Figure 26 illustrates a SEM photograph of a typical coal flyash particle (small, smooth and spherical) and Figure 27 is its corresponding EDX elemental spectral graph depicting high peaks for Si and/or Ca and variable amounts of Al, K, Ti and Fe.

- Figure 28 illustrates a SEM photograph of a typical biological - organic particle (characteristic of pollen or spores) and Figure 29 is its corresponding EDX elemental spectral graph depicting a high peak for background Au only (from the gold coating procedure).

- Figure 30 illustrates a SEM photograph of a typical biological - elemental particle (non-specific) and Figure 31 is its corresponding EDX elemental spectral graph depicting a high peak for background Au only (from the gold coating procedure).

- Figure 32 illustrates a SEM photograph of a typical combustion particle (non-specific) and Figure 33 is its corresponding EDX elemental spectral graph depicting peaks similar to mineral particles with additional peaks for Cl and Zn.

- Figure 34 illustrates a SEM photograph of a typical oil particle (small, smooth and spherical) and Figure 35 is its corresponding EDX elemental spectral graph depicting a high peak for S only.

- Figure 36 illustrates a SEM photograph of a typical salt particle (non-specific) and Figure 37 is its corresponding EDX elemental spectral graph depicting a peak for mainly Cl with detectable Na.

- Additional EDX elemental spectral graphs and SEM photographs for other particle types can be found in Appendix 8.5 SEM Photographs and EDX Spectra. These additional particles include: Rust (Fe), Ca, Pb, K and Ti, among other interesting particles. Appendix 8.5 also includes SEM photographs of the overviews of the blanks (control and field) and some samples for each season.
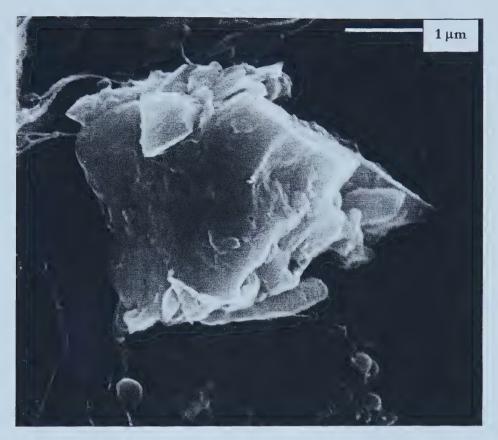
Figure 22. SEM Photograph of a Silica Crystal.
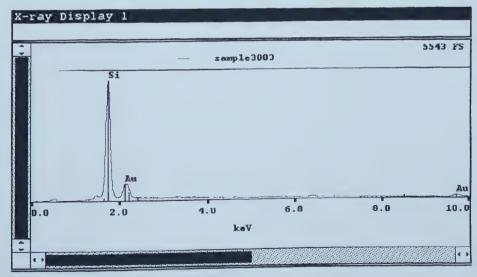
Figure 23. EDX Elemental Spectral Graph of a Silica Crystal.

145
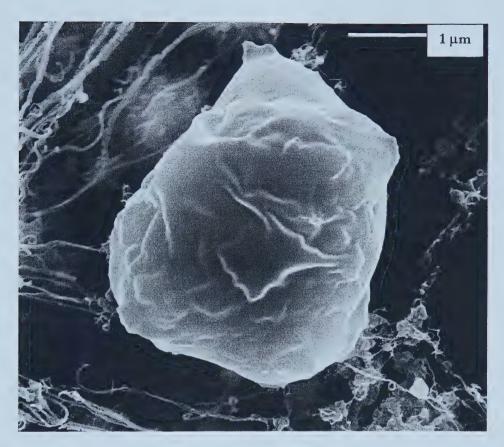
Figure 24. SEM Photograph of a Mineral (Clay) Particle.
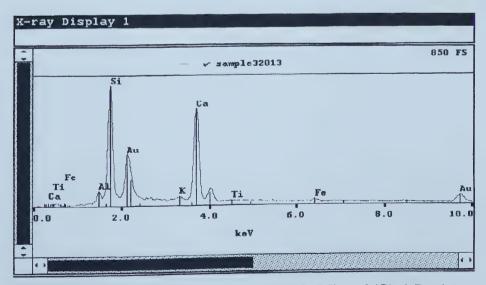
Figure 25. EDX Elemental Spectral Graph of a Mineral (Clay) Particle.

Figure 26. SEM Photograph of a Coal Flyash Particle.
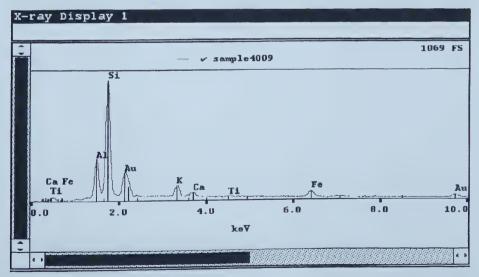
Figure 27. EDX Elemental Spectral Graph of a Coal Flyash Particle.
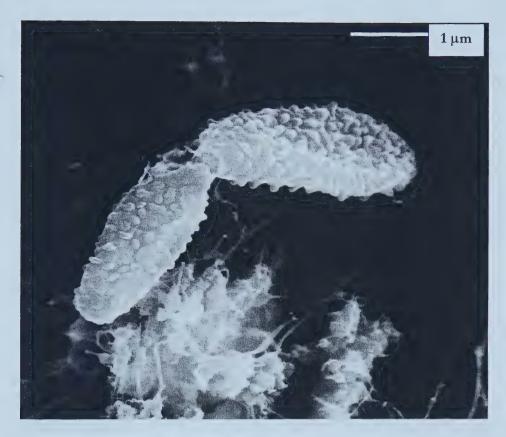
Figure 28. SEM Photograph of a Biological - Organic Particle (Spore).
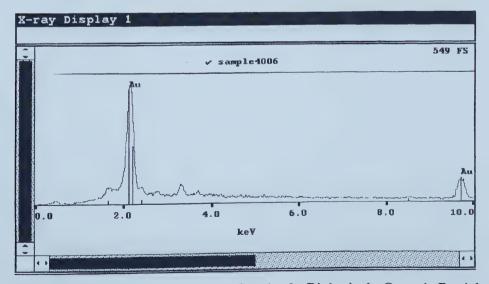
Figure 29. EDX Elemental Spectral Graph of a Biological - Organic Particle (Spore).
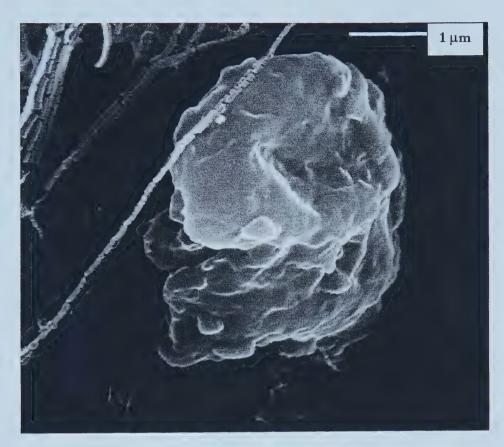
Figure 30. SEM Photograph of a Biological - Elemental Particle.
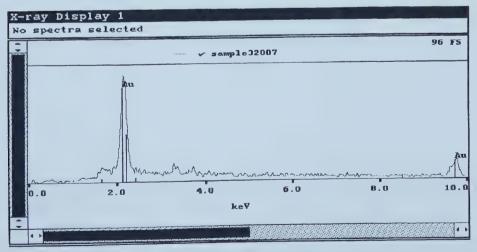
Figure 31. EDX Elemental Spectral Graph of a Biological - Elemental
Particle.
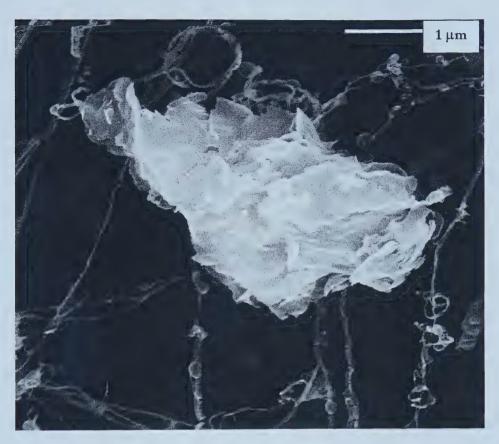
Figure 32. SEM Photograph of a Combustion Particle.
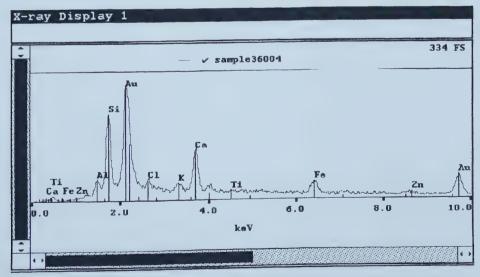
Figure 33. EDX Elemental Spectral Graph of a Combustion Particle.
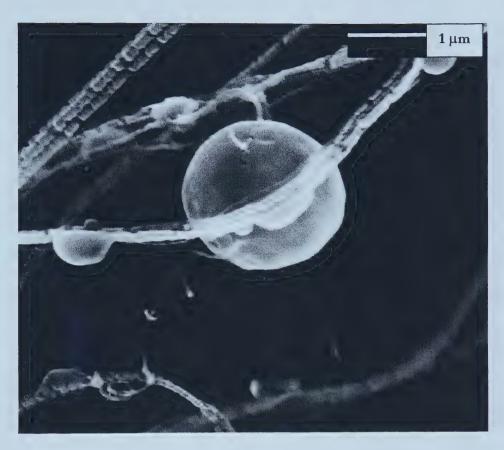
Figure 34. SEM Photograph of an Oil Particle.
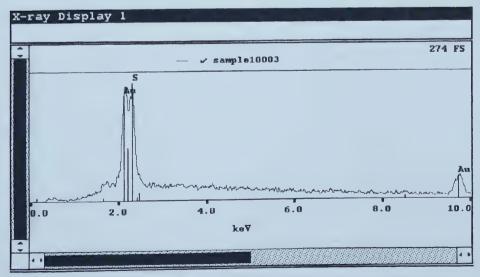
Figure 35. EDX Elemental Spectral Graph of an Oil Particle.

Figure 36. SEM Photograph of a Salt Particle.
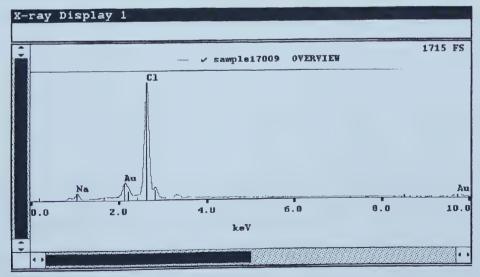
Figure 37. EDX Elemental Spectral Graph of a Salt Particle.

Of the forty-four filter samples and their replicates taken from Devon, Alberta during the two sampling periods (August and October 2000) a total of 917 particles were inspected and analyzed. Use of the SEM enabled classification of individual particles according to their morphologies and gave some insights into possible sources of PM_{10} which otherwise might not have been apparent. Table 13 reveals the number of particles that were incorporated into each particle category.

The first detail noticed is that biological – organics (i.e. insect parts, hairs, plant debris, wood parts, pollen, spores and bacteria) constituted almost 40% of all the particles considered in this study. This is a very substantial amount of the total PM_{10} sampled at the receptor location, but it is not unusual. Many studies have found that organics comprise a large amount of the particulate matter sampled in a given area, particularly when the sampling occurs in the warmer months (Hopke, 1985). This seasonal trend is clearly evident in this study as most of the total amount of organic particles was sampled in August (321) as opposed to October (14). This trend was primarily a result of a substantially larger amount of plant and insect activity in the warmer month of August and because of a higher amount of anthropogenic activities (i.e. agriculture) that gave rise to organic particles.
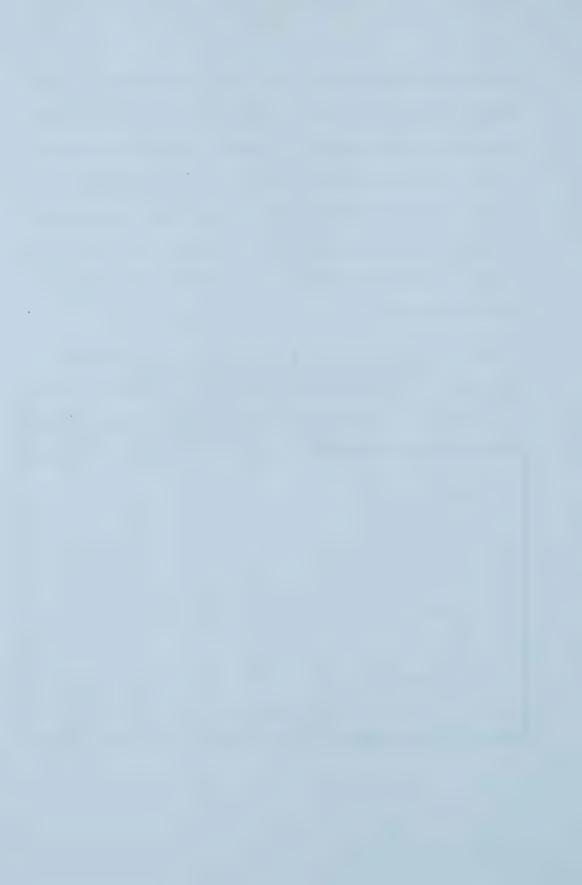
Besides organics, crustal material (silica crystals and mineral particles) combined to account for approximately 40% of the total PM_{10} sampled at the receptor location. This result was expected due to the dominance of sources of crustal material in Devon during the sampling periods (i.e. agricultural activities, construction activities, river valley, road dust and gravel road dust). The SEM analysis was able to show, however, that coal flyash also contributed considerably to

153

the overall levels of PM_{10} in Devon. This deduction would not have been possible with only the results of the elemental analysis because flyash has a very similar elemental profile as mineral particles. In regards to the other particle classifications, biological – elemental, combustion, oil and salt contributed progressively less to the overall total. In terms of seasonal variability, for every particle type category the particle numbers in August and October were very similar except, as mentioned, for biological – organics. This suggests that the sources of PM_{10} in Devon did not vary a great deal over these two sampling seasons, nor did their emission levels.

Table 13. Particle Count for Each Type of Particle Category for August, October and the Entire Sampling Period (Total).

Category	Particle Count		
	August	October	Total
Silica Crystal	63	59	122
Mineral (Clay)	116	115	231
Coal Flyash	35	41	76
Biological - Organic	321	14	335
Biological - Elemental	46	36	82
Combustion	13	22	35
Oil	7	6	13
Salt	4	2	6
Other	11	6	17
Total	**616**	**301**	**917**

5.2.3   Seasonal Variation

Seasonal comparison of results of the SEM-EDX analysis for PM_{10} elemental composition and biological material content for August and October are presented in Figure 38. Elemental composition is presented as a percent relative abundance of the total composition and biological material content is presented as a ratio between the number of biological particles counted per ten particles elementally analyzed. The differences between the PM_{10} elemental abundances for August and October were very small with a few exceptions: Cl, S, Ti and Pb. The abundances of these elements with considerable differences were very low and found mainly in trace amounts. These differences, therefore, were most likely a result of seasonal meteorological variations as opposed to differences in emission types or quantities. The similarity of chemical composition abundances for each season suggests that the sources and emission quantities of PM_{10} during these two seasons were very comparable with the exception of the sources of biological material. The difference between the biological content for August and October was substantial. The ratio for the August sampling season was 1.6 compared to a ratio of 0.20 for October, almost a ten fold disparity. As mentioned earlier, this was not unexpected as biological material concentrations display a seasonal trend whereby larger quantities are more evident during the warmer months (Hopke, 1985). This was primarily a result of a substantially larger amount of plant and insect activity, anthropogenic activities such as agriculture, and sources such as wild fires, and prescribed agricultural and biomass burning in the warmer month of August.
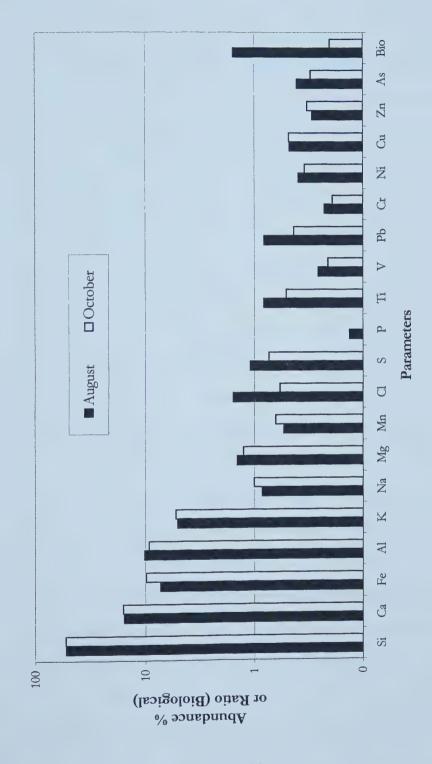
Figure 38. Results of the SEM-EDX PM$_{10}$ Elemental Analysis Comparing the August and October Sampling Periods.

5.2.4   Meteorological Influences

Meteorological conditions affect not only the particulate matter concentration, but also its chemical composition. Factors such as temperature, wind speed and relative humidity can modify the concentrations and types of elements which make-up particulate matter. The most important factors are wind direction and precipitation (Keith, 1991). Wind direction has the most significant influence because a change in wind direction can dictate the type and impact of sources and can therefore induce large variations in the types and amounts of certain elemental species collected in a short period of time at a specific location. Precipitation can also have a number of effects. As a general rule, precipitation reduces the overall amount of particulate matter and therefore the elemental concentration of certain species. It can, however, have the opposite effect by encouraging plant activity (i.e. pollination) thereby increasing the amount of biological material in the atmosphere.

Meteorological data were taken from the local meteorological conditions for the Edmonton International Airport located approximately 20 km east of Devon (Appendix 8.3 Meteorological Data) (Environment Canada, 2000) and used in conjunction with the chemical composition data (Appendix 8.4 Raw Chemical Composition Data) to illustrate the influence that meteorology had on the PM_{10} composition in this study. The effect of wind direction is demonstrated in Figures 39 and 40. In Figure 39, the maximum mass concentration occurrences of arsenic for the entire sampling period are compared to wind direction. Maximum mass concentration occurrences are those concentrations that are greater than the average

157
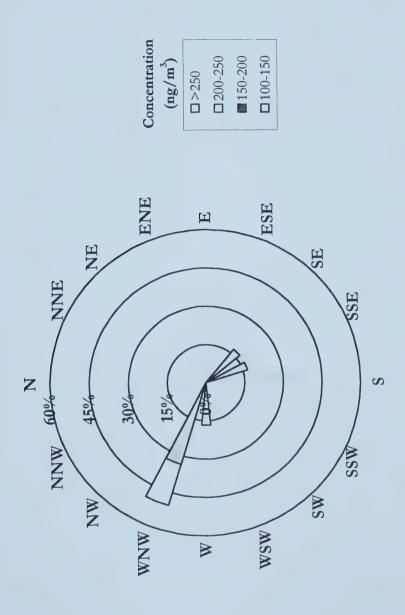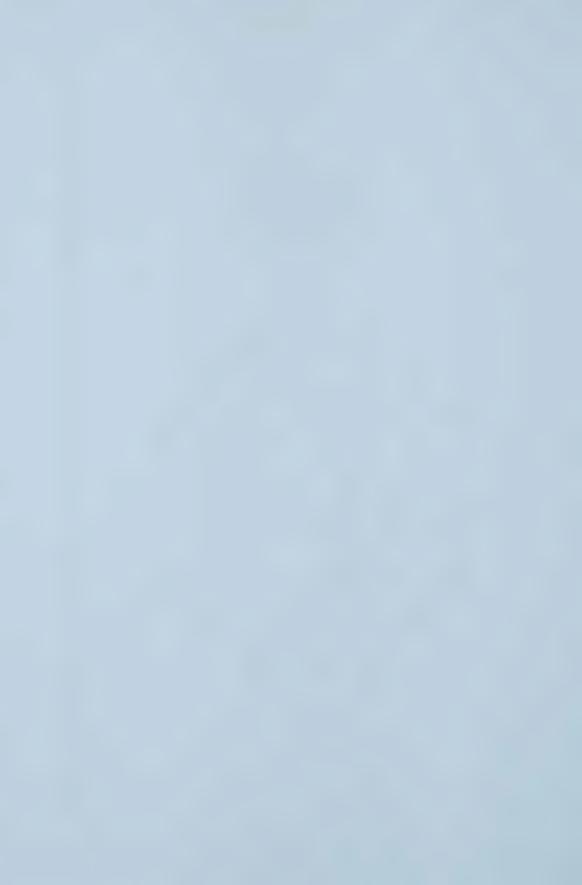
Figure 39. Wind Rose for the Maximum Mass Concentration Occurrences of Arsenic for the Entire Sampling Period.

Concentration
(ng/m^3)

■ >1200
□ 900-1200
□ 600-900
■ 400-600
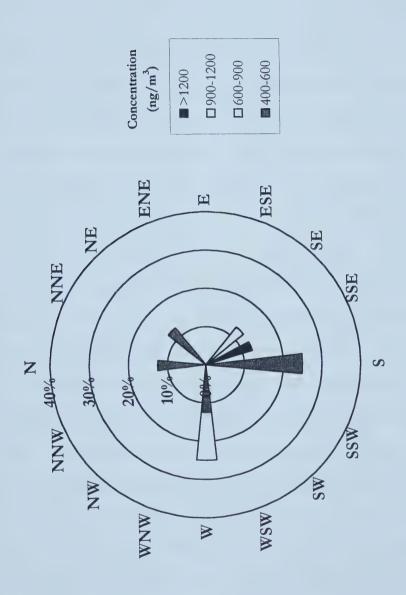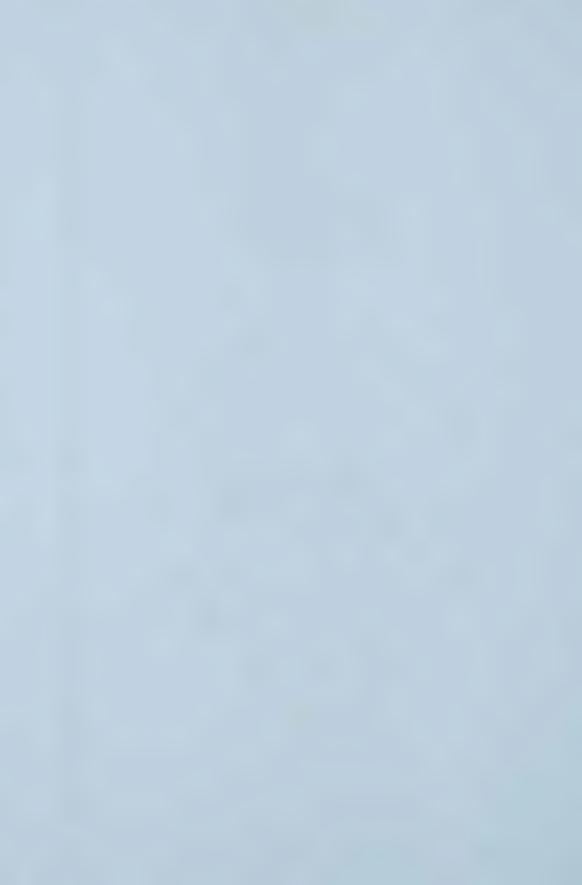
Figure 40. Wind Rose for the Maximum Mass Concentration Occurrences of Sulphur for the Entire Sampling Period.

mass concentration plus one standard deviation. Thus, a mass concentration was considered maximum if it was greater than 45 ng/m^3 plus 55 ng/m^3 (100 ng/m^3). The results indicate that about 67% of the maximum mass concentration occurrences of arsenic detected at the receptor location were originating from the west and west-northwest. The rest, approximately 33%, were originating from other directions (mostly from the southeast). This suggests that the arsenic detected at the receptor location was predominantly originating from one point source or a number of point sources in the west and west-northwest. Known point sources to the west and west-northwest of Devon that could account for this included numerous coal-fired power plants approximately 50 km away. As arsenic is a known distinctive marker element for coal combustion (Chow, 1995), it is probable that these power plants were influencing the PM$_{10}$ levels and characteristics at the receptor location in Devon due to the long-range transport of particulate flyash.

Figure 40 serves to demonstrate the effect wind direction had on the chemical composition of particulate matter that was not originating from a point source. This figure shows the maximum mass concentration occurrences of sulphur for the entire sampling period compared to wind direction. In this example, a mass concentration was considered maximum if it was greater than the average (95 ng/m^3) plus one standard deviation (305 ng/m^3) or 400 ng/m^3. The results indicate that the maximum mass concentration occurrences of sulphur detected at the receptor location were originating more equally from all directions when compared to those of arsenic. This would imply that the sulphur detected at the receptor location was occurring as a result of a more ubiquitous source. Such a source can include

background regional sulphate due to the high amount of oil and gas activity in Alberta. As a result of this activity, background regional sulphate is found in substantial concentrations in Alberta as compared to neighboring provinces and states (Cheng et al., 1998).

The influence that precipitation had on the composition of particulate matter in this study is demonstrated in Figures 41 and 42. In Figure 41, the daily mass concentration of sulphur for the August sampling period is compared to total daily precipitation. This figure clearly shows that when precipitation occurred concentrations of sulphur were absent and when precipitation ceased they quickly rebounded. This result was due to precipitation scavenging background sulphates from the atmosphere and new parcels of air containing sulphates quickly entering the area when the events ended. This is slightly different than precipitation inhibiting the suspension of crustal material because of the compaction of ground level material, which can extend the time required for concentrations to rebound.

Precipitation can have another effect on the composition of particulate matter. In Figure 42, the biological content (presented as a ratio between the number of biological particles counted per ten particles elementally analyzed) for the August sampling period is compared to precipitation. This figure reveals that the amount of biological material in the atmosphere increased significantly immediately following a precipitation event. This effect was due to the water from the precipitation event infiltrating into the soil and plant stomata, thereby encouraging plant growth and activity (i.e. pollination); this, in turn, increased the amount of biological material in the atmosphere.

161
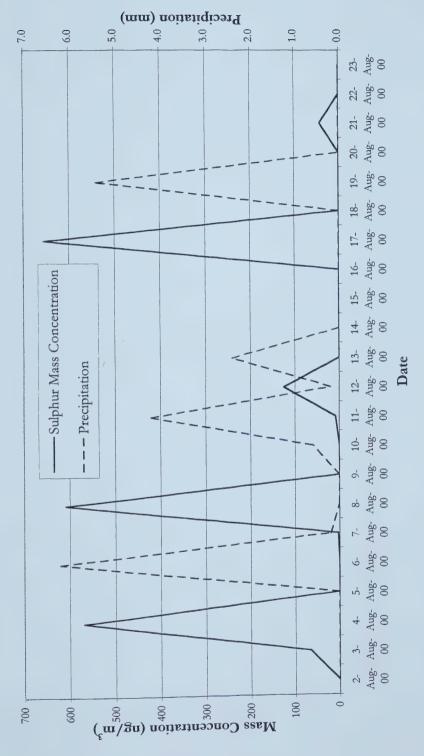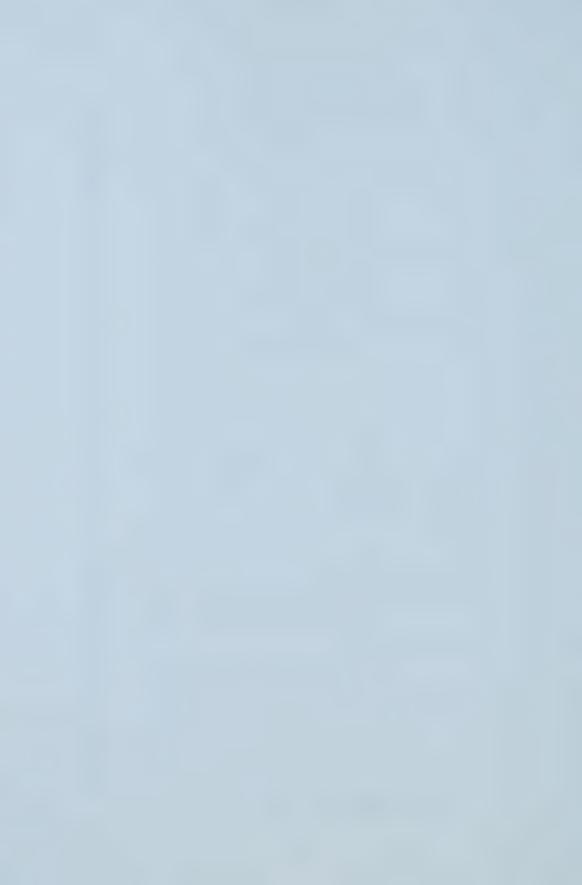
Figure 41. Comparison of the Sulphur Mass Concentration and Precipitation for the August Sampling Season.
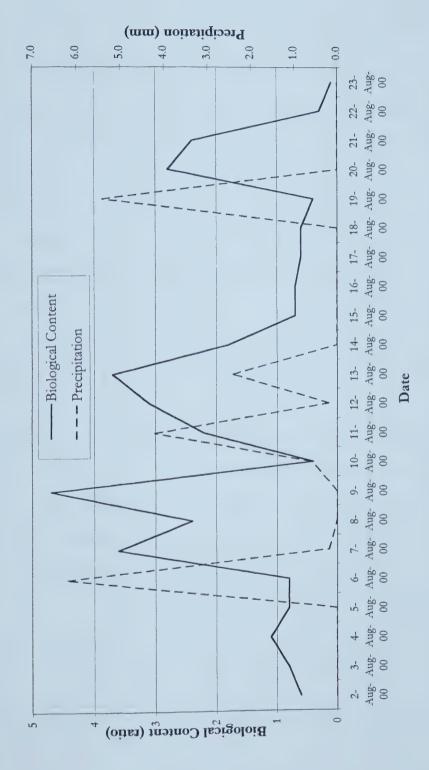
Figure 42. Comparison of the Biological Content and Precipitation for the August Sampling Season.

5.3 Particulate Matter Source Apportionment Results

A principle component analysis (PCA) was performed using elemental abundance data provided by the SEM-EDX analysis of particulate matter (PM_{10}) collected on filters. A total of forty-four filters were analyzed by SEM-EDX for a total of nineteen elements (Si, Ca, Fe, Al, K, Na, Mg, Mn, Cl, S, P, Ti, V, Pb, Cr, Ni, Cu, Zn and As). These elements were chosen for analysis because of their suspected abundances, strong tracer characteristics, and a qualitative knowledge of possible SEM-EDX elemental interference problems (Braybrook, 2001). The PCA preparation and execution adhered to the techniques and protocols outlined in Section 4.3 Data Analysis. Specifically, using the TEOM mass concentration data ($\mu g/m^3$) and the elemental abundance (%) results from the SEM-EDX analysis, elemental concentrations (ng/m^3) were determined for each of the forty-four filters (Appendix 8.3). The elemental concentration data for each of the nineteen elements were first standardized by calculating the z-scores. The z-scores were then used in conjunction with SYSTAT Version 9.0® for the PCA utilizing a Varimax rotation (SPSS, 2000). Elements were subsequently eliminated and the PCA repeated until all criteria for regional background receptor models, as outlined in Section 4.3.2, were satisfied. This procedure resulted in a total of four factors with eigenvalues greater than one (eigenvalues which are less than one were presumably dominated by error variance (Thurston and Spengler, 1985)) that combined to account for 86% of total variance of the original data set. A step-by-step account of how this result was achieved is given below.

PCA was initially conducted using the data from each of nineteen elements for which the SEM-EDX analyzed. This analysis resulted in six factors with eigenvalues greater than one that combined to account for 76% of total variance of the original data set (Table 14). Upon inspection of the factor loadings, no clear associations of elements with factors led to an identification of a source or source category, and therefore further analysis was required.

Table 14. Results of the PCA - Step 1.

Factors	1	2	3	4	5	6
Si	0.87	0.14	-0.02	-0.12	0.00	0.16
Ca	0.61	-0.17	0.08	0.02	-0.56	0.01
Fe	0.91	0.15	-0.12	-0.01	0.11	-0.05
Al	0.85	0.10	-0.07	-0.04	0.01	0.27
K	0.76	-0.01	0.08	0.19	0.02	0.37
Na	0.04	-0.04	0.88	0.18	0.01	-0.06
Mg	0.64	-0.11	-0.06	0.10	-0.18	0.39
Mn	0.66	0.27	-0.09	0.20	0.06	-0.21
Cl	-0.60	0.02	0.04	0.88	0.04	-0.01
S	-0.07	0.11	0.91	-0.08	0.05	0.07
P	-0.13	0.04	-0.08	-0.04	-0.91	-0.01
Ti	0.16	0.26	0.01	-0.04	0.03	0.84
V	0.43	0.53	0.12	0.42	0.06	0.28
Pb	0.00	0.80	-0.07	-0.22	-0.02	0.13
Cr	0.58	0.56	0.04	0.31	-0.08	-0.09
Ni	0.69	0.48	0.20	0.18	0.11	0.17
Cu	0.68	0.38	0.18	-0.04	-0.01	-0.09
Zn	0.56	0.34	0.20	0.49	-0.05	-0.10
As	0.24	0.81	0.09	0.31	0.07	0.13
Eigenvalue	7.27	2.19	1.60	1.29	1.14	1.01
Variance Explained by Rotated Components	5.96	2.62	1.79	1.61	1.22	1.31
Percent of Total Variance Explained	31.39	13.76	9.44	8.47	6.43	6.88

The PCA was repeated after eliminating those elements that had low abundances or that were thought to have been unreliably determined by the SEM-EDX analysis. The elements eliminated were P, which was only detected on two filters, and Na, which has been shown to be unreliably detected by the SEM-EDX analysis because of spectral interferences (Gordon et al., 1981). This analysis resulted in five factors with eigenvalues greater than one that combined to account for 75% of total variance of the original data set (Table 15).

Table 15. Results of the PCA - Step 2.

Factors	1	2	3	4	5
Si	0.69	0.53	0.15	-0.15	-0.18
Ca	0.52	0.35	-0.33	-0.05	-0.07
Fe	0.55	0.70	0.03	-0.19	-0.12
Al	0.75	0.47	0.14	-0.12	-0.10
K	0.76	0.37	0.01	0.08	0.15
Mg	0.77	0.18	-0.03	-0.08	0.10
Mn	0.21	0.75	-0.01	-0.02	0.07
Cl	-0.05	0.08	-0.02	-0.11	0.88
S	-0.14	0.13	-0.05	0.91	-0.08
Ti	0.59	-0.18	0.48	0.40	0.06
V	0.32	0.48	0.41	0.25	0.42
Pb	-0.05	0.18	0.86	-0.15	-0.14
Cr	0.21	0.75	0.28	0.04	0.23
Ni	0.43	0.67	0.33	0.23	0.14
Cu	0.30	0.71	0.17	0.12	-0.11
Zn	0.21	0.70	0.05	0.15	0.41
As	0.05	0.50	0.67	0.15	0.33
Eigenvalue	7.25	2.02	1.32	1.15	1.01
Variance Explained by Rotated Components	3.66	4.40	1.96	1.29	1.44
Percent of Total Variance Explained	21.54	25.89	11.52	7.58	8.47

The PCA was repeated again after eliminating those elements that were clearly not distinctive to one source or factor. This determination was made based on a criterion that any element which had a factor loading greater than ± 0.4 for three or more factors was not indicative of any one source. The elements that did not satisfy this condition included Ti and V, as both were strongly associated with three factors. This analysis resulted in four factors with eigenvalues greater than one that combined to account for 72% of total variance of the original data set (Table 16).

<p style="text-align:center">Table 16. Results of the PCA - Step 3.</p>

Factors	1	2	3	4
Si	0.87	-0.05	0.27	-0.06
Ca	0.67	0.01	-0.22	0.05
Fe	0.86	0.11	0.21	-0.05
Al	0.87	-0.01	0.21	-0.09
K	0.78	0.20	0.05	0.07
Mg	0.73	0.02	-0.02	-0.10
Mn	0.57	0.37	0.19	0.13
Cl	-0.11	0.87	-0.04	-0.16
S	-0.11	-0.05	0.00	0.93
Pb	-0.01	-0.15	0.90	-0.14
Cr	0.51	0.46	0.48	0.19
Ni	0.64	0.30	0.47	0.31
Cu	0.61	0.09	0.39	0.30
Zn	0.49	0.57	0.24	0.29
As	0.17	0.41	0.76	0.18
Eigenvalue	6.64	1.87	1.23	1.10
Variance Explained by Rotated Components	5.50	1.76	2.30	1.29
Percent of Total Variance Explained	36.64	11.73	15.34	8.59

The PCA was repeated a fourth time after eliminating those elements that were clearly not distinctive to one source or factor in a similar fashion to the previous step. The element that did not satisfy this condition was Cr, as it was strongly associated with three factors. This analysis resulted in four factors with eigenvalues greater than one that combined to account for 73% of total variance of the original data set (Table 17).

Table 17. Results of the PCA - Step 4.

Factors	1	2	3	4
Si	0.87	-0.06	0.26	-0.07
Ca	0.67	-0.05	-0.26	0.04
Fe	0.87	0.07	0.19	-0.05
Al	0.88	-0.03	0.19	-0.09
K	0.79	0.19	0.03	0.07
Mg	0.72	0.00	-0.04	-0.11
Mn	0.60	0.30	0.15	0.14
Cl	-0.07	0.90	-0.01	-0.13
S	-0.11	-0.06	-0.01	0.93
Pb	0.01	-0.13	0.91	-0.12
Ni	0.66	0.26	0.44	0.32
Cu	0.63	0.09	0.38	0.30
Zn	0.52	0.55	0.23	0.31
As	0.22	0.38	0.75	0.20
Eigenvalue	6.08	1.76	1.22	1.10
Variance Explained by Rotated Components	5.39	1.49	2.01	1.27
Percent of Total Variance Explained	38.51	10.66	14.33	9.10

The PCA was repeated a fifth time after eliminating those elements that are known to be a distinctive tracer for more than one source and were, therefore, adding confusion and uncertainty to the analysis. The results of the PCA up to this

point indicated the possible identity of the first two factors. The fact that they appeared to be crustal material and coal emissions suggested that the classic problem of distinguishing between the source profiles of the two (Gordon et al., 1981) was adding confusion and uncertainty to the analysis. Consequently, those elements that are normally used to mark both crustal material and coal emissions as sources were eliminated from further analysis (i.e. Si, Ca, Al, K and Mg). Fe was retained for further analysis even though it is usually a part of both source profiles, because it is more strongly associated with crustal material (Gordon et al., 1981). This analysis resulted in four factors with eigenvalues greater than one that combined to account for 81% of total variance of the original data set (Table 18).

Table 18. Results of the PCA - Step 5.

Factors	1	2	3	4
Fe	0.91	0.03	-0.08	-0.21
Mn	0.82	-0.03	0.08	-0.08
Cl	0.02	0.01	0.95	-0.07
S	0.01	-0.01	-0.04	0.96
Pb	0.03	0.94	-0.11	-0.10
Ni	0.77	0.36	0.14	0.22
Cu	0.75	0.28	-0.05	0.18
Zn	0.68	0.18	0.44	0.21
As	0.38	0.74	0.31	0.16
Eigenvalue	3.83	1.26	1.12	1.09
Variance Explained by Rotated Components	3.26	1.66	1.24	1.14
Percent of Total Variance Explained	36.22	18.49	13.75	12.68

The PCA was repeated a sixth time after eliminating those elements that were not significantly contributing any further tracer information in identifying a source. As the first factor was initially identified as crustal material, both Ni and Cu served no further use in the analysis primarily because they are only strongly associated with the first factor, and Fe and Mn had already supplied the necessary marker information to classify this source. (It should be remembered that these elements did aid in the PCA and should not be ignored automatically prior to analysis since information on unknown sources thus may be lost). This analysis resulted in four factors with eigenvalues greater than one that combined to account for 86% of total variance of the original data set (Table 19).

Table 19. Results of the PCA - Step 6.

Factors	1	2	3	4
Fe	0.92	0.09	-0.06	-0.14
Mn	0.89	0.05	0.06	0.03
Cl	0.00	0.00	0.95	-0.08
S	-0.04	0.00	-0.04	0.98
Pb	-0.03	0.94	-0.10	-0.11
Zn	0.60	0.22	0.49	0.22
As	0.34	0.77	0.29	0.20
Eigenvalue	2.59	1.26	1.11	1.03
Variance Explained by Rotated Components	2.12	1.54	1.24	1.08
Percent of Total Variance Explained	30.29	22.06	17.76	15.43

The results of the PCA were compared to previous studies, relevant literature, and particulate matter databases (including the U.S. Environmental Protection Agency's SPECIATE database (U.S. EPA, 1993)) to identify and categorize the most likely sources of PM_{10} at the receptor location. The result of the PCA are presented again in Table 20 with the factors labeled as probable sources and with only those factor loadings that indicated an element was strongly associated with a particular source shown (i.e. greater than ± 0.4).

Table 20. Results of the PCA Summarized by Source.

Sources	Crustal Material	Coal Emissions	Combustion	Regional Sulphate
Fe	0.9			
Mn	0.9			
Cl			1.0	
S				1.0
Pb		0.9		
Zn	0.6		0.5	
As		0.8		
Eigenvalue	2.6	1.3	1.1	1.0
Variance Explained by Rotated Components	2.1	1.5	1.2	1.1
Percent of Total Variance Explained	30.3	22.1	17.8	15.4

The first factor was identified as crustal material due to its strong association with the lithophilic marker elements iron and manganese (Beceiro-Gonzalez et al., 1997). Zinc, which is considered to make up an important part of the chemical profile of crustal material (Hammerle and Pierson, 1975; Chow, 1995), also had a significant association to this factor. As stated previously, the procedure developed

171

for applying PCA in regional background studies has a downside in that a more specific identification of a source is not possible. Therefore, the sources of crustal material could have included such things as agricultural activities, undisturbed soil, paved roads, unpaved roads, construction and others (Weir and Ireson, 1988).

The second factor was clearly recognized as coal emissions because of its strong association to the very distinctive marker elements arsenic and lead (Parekh and Husain, 1981; Fung and Wong, 1995; Alves et al., 1998a). This coal component was most likely the result of the long-range transport of coal flyash from the numerous coal-fired power plants situated over 50 km to the west and west-northwest of the receptor location. This supposition was validated by the detection and identification of a substantial amount of individual coal flyash particles by the SEM (see Section 5.2.2 Morphology) and by the wind direction analysis indicating most of the arsenic detected at the receptor location was originating from the west and west-northwest (see Section 5.2.4 Metrological Influences).

The third factor was identified as the total of contributions from numerous combustion sources. Again, a more specific identification of a source was not possible with this type of analysis. These combustion sources could have included: biomass burning, refuse incineration, vehicle combustion, forest fires and residential wood burning. The presence of chlorine would initially indicate that the source was a salt aerosol. However, as this study was conducted in the summer and fall months, no road salt was used in the area for de-icing activities. In addition, there were no marine aerosol sources for thousands of kilometers. The most important source for chlorine, after salt aerosols, is considered to be combustion activities (Marcazzan,

1998; U.S. EPA, 1993). Its moderate association with zinc further supported the labeling of this factor as combustion sources. Zinc is highly indicative of combustion processes such as refuse incineration, biomass and vegetation burning, and vehicular fuel and oil combustion (Lowenthal and Rahn, 1987; Morales et al., 1990; Sharma and Singh, 1992; Huang et al., 1994).

The final factor, factor four, had only one element for which it was strongly associated. The sulphur component, in this situation, was identified as a background regional sulphate source (Dzubay et al., 1988). Sulphate has long been recognized as a regional pollutant. As it is formed slowly into secondary aerosols from SO_2 via atmospheric chemistry while traveling distances of hundreds of kilometers, its ambient levels are not much affected by local sources. Concentrations are only slightly higher in urban areas than in surrounding rural areas (Tuncel et al., 1985). Wind direction analysis indicated that the sulphur detected at the receptor location originated from all directions more or less equally (see Section 5.2.4 Metrological Influences), thereby suggesting that the sulphur source is more of a ubiquitous source than a point source. This background regional sulphate was likely due to the high amount of oil and gas activity in Alberta (that often results in gas flaring and other industrial processes), emissions from coal-fired power plants, and emissions from other primary industrial sources that cannot be singled-out. This assertion is validated by Cheng et al. (1998), who report that Alberta has higher levels of SO_2, NO_x and VOCs compared to all bordering provinces and states, and that for Edmonton and Calgary the largest mass fraction of the fine particulate matter, which is incorporated in PM_{10}, is sulphate.

The results of the source apportionment reveal that PM_{10} sampled at the representative receptor location in Devon, Alberta was composed of the contributions of at least four sources (not including biological material), which combined to account for 86% of total variance of the original data set (Figure 43). The largest contribution was from sources of crustal material and accounted for 30% of the PM_{10} sampled. The next most significant source, contributing 22%, was coal emissions originating most likely from long-range transport of coal flyash from the numerous coal-fired power plants located to the west and northwest. Combustion sources and regional background sulphate contributed 18% and 15% of the PM_{10}, respectively. A total of 14% of the PM_{10} at the receptor location originated from unknown sources that could not be explained by the PCA.
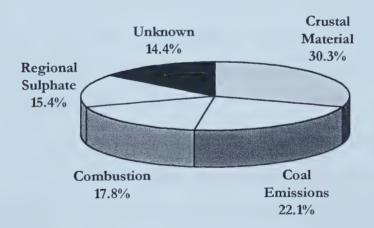
Figure 43. Sources of PM_{10} in Devon, Alberta.

CHAPTER 6: CONCULSIONS AND RECOMMENDATIONS

An extensive ambient air sampling program was conducted during August and October of 2000 in Devon, Alberta in order to provide detailed information on characteristics and sources of regional background inhalable particulate matter (PM_{10}) in Alberta.

The first objective of the study was to determine the ambient levels of the PM_{10} in a regional background community, explore any seasonal variation, evaluate meteorological impacts, and compare the results with those of similar studies and current regulations. The results of the study show:

- The ambient 1-hour and 24-hour average PM_{10} levels observed in Devon were low (i.e. <20 $\mu g/m^3$) for most of both sampling seasons. The mean 1-hour average concentration for the entire sampling period was 13 $\mu g/m^3$ and the mean 24-hour average concentration for the entire sampling period was 13 $\mu g/m^3$.

- There was a discernable seasonal difference between the 24-hour average concentrations. The mean concentration for the August sampling season was 11 $\mu g/m^3$ and the mean 24-hour average concentration for the October sampling period was 15 $\mu g/m^3$.

- Meteorological phenomena played an important role in the determination of ambient PM_{10} levels. Wind direction, temperature, wind speed and precipitation each had a measurable influence on the PM_{10} levels.

- In comparison to other studies, the levels measured in this study were as expected (i.e. similar to other regional background studies, higher than rural remote studies, and lower than rural industrial and urban studies). The 24-hour average concentrations measured over the two sampling seasons were not in violation of current regulations of selected jurisdictions.

The second objective of the study was to ascertain the elemental composition and morphology of the PM_{10} in a regional background community, explore any seasonal variation, and evaluate meteorological impacts. The results of the study show:

- The PM_{10} sampled was dominated by lithophilic elements (i.e. Si, Ca, Fe, Al, K and Mg) and biological material. However, numerous trace metals were also detected in addition to elements such as S, V and Cl. The morphology of the PM_{10} sampled was such that each particle analyzed could be assigned to a specific particle category. The particle categories with the highest particle counts were (in descending order): biological – organic, mineral (clay), silica crystal, biological – elemental, coal flyash, and combustion.

- There was very little difference between the PM_{10} elemental abundances for August and October. However, the difference between the biological content

for the two seasons was quite substantial with much more having been detected during August.

- Meteorological phenomena significantly influenced the chemical and biological content of the PM_{10} sampled. Wind direction and precipitation each had a bearing on the types and amounts of the elements and biological material which made-up the PM_{10}.

The third objective of the study was to establish the sources of the PM_{10} in a regional background community and evaluate their contributions to overall levels. The results of the study show:

- The PM_{10} collected during the two sampling seasons originated from four main source categories that combined to account for 86% of the total amount of particulate matter collected. The largest contribution came from crustal material sources (30%) followed by coal emissions (22%), combustion sources (18%) and regional sulphate (15%).

As with most detailed studies it becomes apparent that there are improvements in methods and approaches which might yield further useful information. There are also numerous avenues of research that could not be addressed within the constraints of the current study but which could improve the foundation of knowledge pertaining to particulate matter. Some of these improvements and suggestions are noted here:

- Additional useful information on seasonal and long-term variability could have been obtained if this research had been conducted over a one-year period.

- Additional useful information on spatial variability could have been obtained if this research had been conducted at multiple sites.

- A complementary study should be conducted in Devon to determine the characteristics and sources of regional background $PM_{2.5}$.

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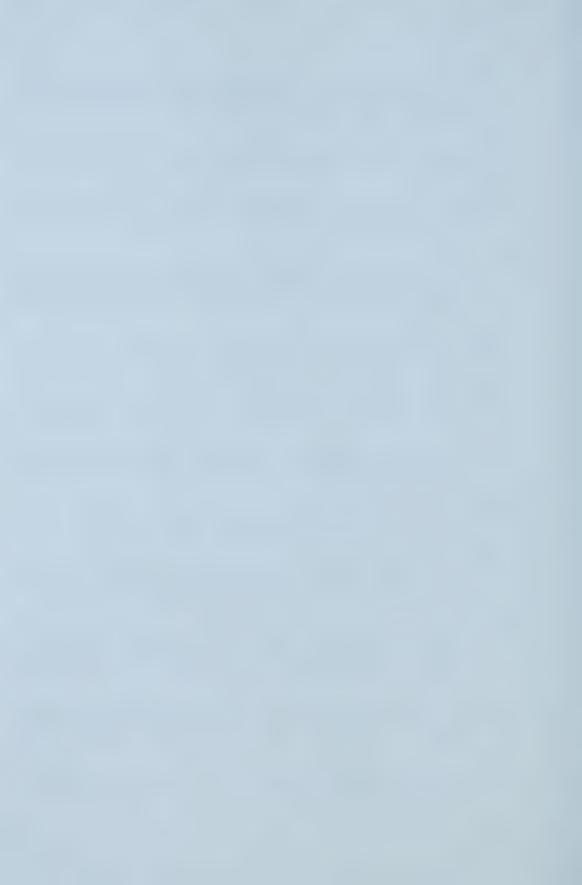
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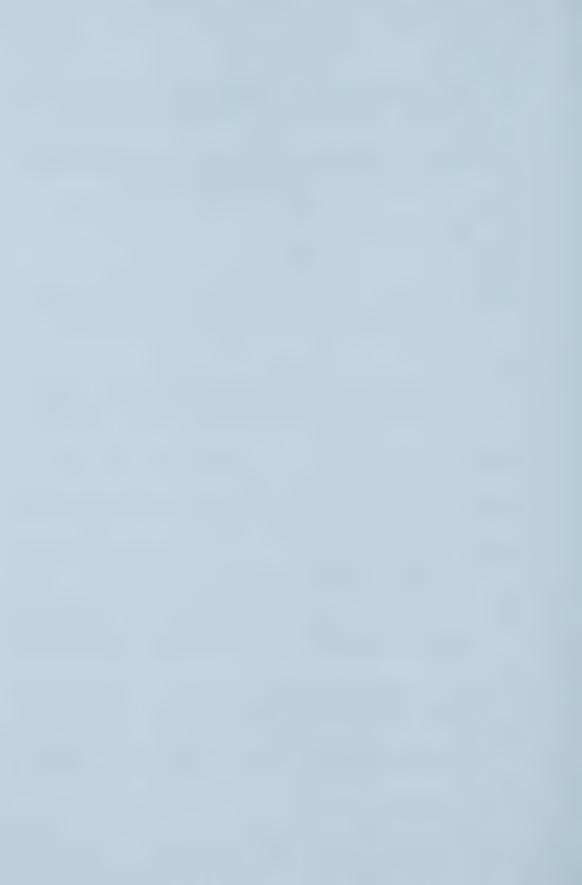
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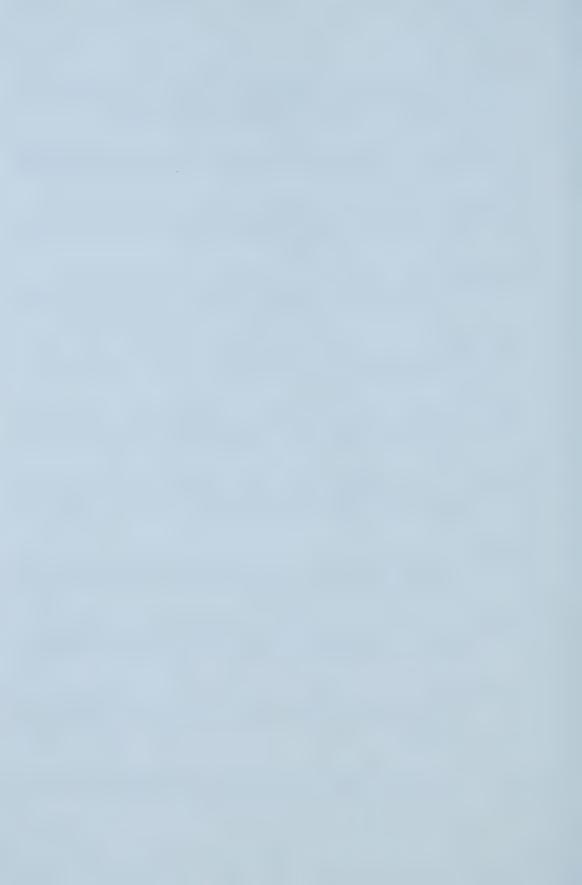
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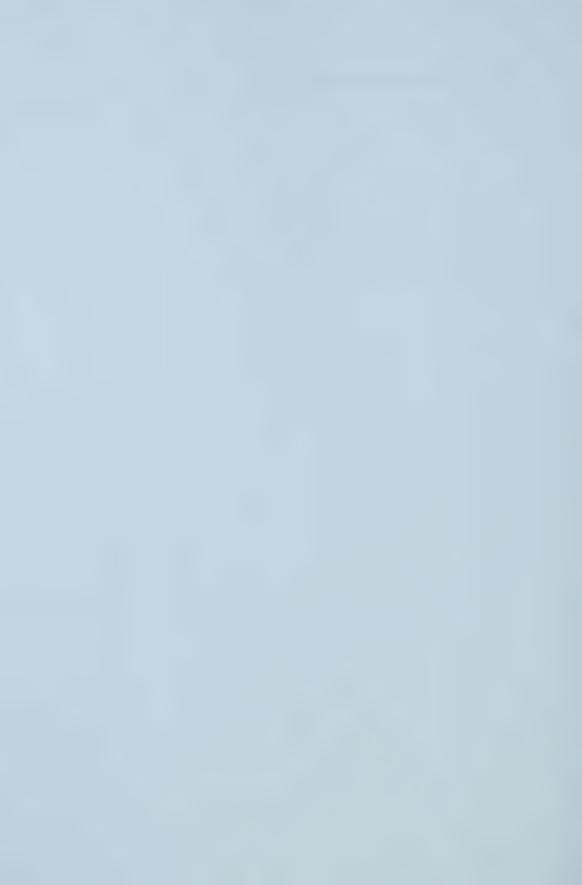
CHAPTER 8: APPENDICES

8.1 Field Data Log Forms

Particulate Matter (PM10) MiniVol and TEOM Sampling Field Data Log

Devon AQ Study Summer and Fall of 2000

Sampling Date:

Field Scientist: _____

Start:

Atm Press [mmHg]	Wind	**End:**	Wind
Amb Temp [°C]	R.H. [%]	Atm Press [mmHg]	R.H. [%]
		Amb Temp [°C]	

Site ID	Sample Type	Sampler ID	Battery ID	Filter ID	Start			End		
					Clock time	Elap time	Roto Flow	Clock time	Elap time	Roto Flow
Devon	PM10									

Filter Type: Sample | Replicate | Control Blank | Field Blank

MiniVol Operating Condition:

start:

end:

TEOM Operating Condition:

start:

end:

Observations:

SEM-EDX PM10 Analysis Data Log

Devon AQ Study Summer and Fall of 2000

Analysis Date: _____

Lab Scientist: _____

Sample Type: Air

Sample Category: Sample   Replicate

Sample #: _____

Location: _____

Control Blank   Field Blank

SEM Photographs: Description and File Name

Photo 1: _____	Photo 6: _____
Photo 2: _____	Photo 7: _____
Photo 3: _____	Photo 8: _____
Photo 4: _____	Photo 9: _____
Photo 5: _____	Photo 10: _____

# of Particles Analyzed: _____

# of Elemental Abundance Records: _____

File Names: _____

# of Elemental Spectral Graphs: _____

Observations:

8.2 Raw TEOM Data

Date	Time	Mass Concentration ($\mu g/m^3$)	30-min Concentration ($\mu g/m^3$)	1-hr Concentration ($\mu g/m^3$)	24-hr Concentration ($\mu g/m^3$)	Total Mass (μg)	Temperature (^oC)	Pressure (atm)
1-Aug-00	12:00 PM	21.7	11.8	12.4	15.7	58.86	21.5	0.926
1-Aug-00	12:30 PM	14.4	15.6	12.4	15.7	59.96	20.5	0.926
1-Aug-00	1:00 PM	33.3	32	23.8	15.6	62.51	22.6	0.927
1-Aug-00	1:30 PM	51.1	66.2	23.8	15.6	68.03	19.9	0.927
1-Aug-00	2:00 PM	22.9	30	48.1	16.5	70.38	22.3	0.927
1-Aug-00	2:30 PM	26.9	27.7	48.1	16.5	72.54	21.7	0.928
1-Aug-00	3:00 PM	12.4	17.4	22.6	16.6	73.79	26	0.928
1-Aug-00	3:30 PM	34.9	28.1	22.6	16.6	76	22.1	0.928
1-Aug-00	4:00 PM	19	27.1	27.6	17	78.1	23.9	0.927
1-Aug-00	4:30 PM	19.5	19.4	27.6	17	79.54	26	0.928
1-Aug-00	5:00 PM	16.2	16	17.7	16.9	80.67	24.2	0.928
1-Aug-00	5:30 PM	18.2	15.8	17.7	16.9	81.8	19.7	0.928
1-Aug-00	6:00 PM	12.4	13.1	14.5	16.8	82.68	18.9	0.928
1-Aug-00	6:30 PM	14.2	14	14.5	16.8	83.64	18.2	0.928
1-Aug-00	7:00 PM	13.9	18.9	16.4	16.8	85.03	18.2	0.929
1-Aug-00	7:30 PM	15.2	16.3	16.4	16.8	86.18	16.9	0.929
1-Aug-00	8:00 PM	20.2	17.6	17	16.6	87.47	15	0.929
1-Aug-00	8:30 PM	10.6	13	17	16.6	88.34	12.8	0.929
1-Aug-00	9:00 PM	7.2	9	11	16.2	88.86	12.1	0.928
1-Aug-00	9:30 PM	7.5	7.7	11	16.2	89.27	12.1	0.928
1-Aug-00	10:00 PM	7.6	7.9	7.8	15.7	89.7	11.9	0.928
1-Aug-00	10:30 PM	8.6	8.6	7.8	15.7	90.19	11.8	0.929
1-Aug-00	11:00 PM	7.8	8.2	8.4	15.4	90.65	11.7	0.929
1-Aug-00	11:30 PM	7.1	7	8.4	15.4	90.99	10.9	0.929
2-Aug-00	12:00 AM	6.5	9.3	8.1	15	91.55	10.5	0.929
2-Aug-00	12:30 AM	6.6	6.8	8.1	15	91.88	9.8	0.929
2-Aug-00	1:00 AM	5.7	6	6.4	14.7	92.14	9.6	0.929
2-Aug-00	1:30 AM	5.4	6.2	6.4	14.7	92.42	8.8	0.928
2-Aug-00	2:00 AM	7.6	6.2	6.2	14.4	92.71	8.7	0.928
2-Aug-00	2:30 AM	6.2	6.1	6.2	14.4	92.98	8.4	0.928
2-Aug-00	3:00 AM	5.9	6.4	6.2	14.2	93.27	8.3	0.928
2-Aug-00	3:30 AM	5.2	5.7	6.2	14.2	93.51	8.1	0.928
2-Aug-00	4:00 AM	7	6.3	6	14.1	93.8	7.3	0.928
2-Aug-00	4:30 AM	6.8	6.8	6	14.1	94.13	7.3	0.928
2-Aug-00	5:00 AM	6.5	6.9	6.8	14	94.47	8	0.927
2-Aug-00	5:30 AM	5.6	6.5	6.8	14	94.77	8.5	0.927
2-Aug-00	6:00 AM	6.7	6.4	6.5	14	95.08	7.9	0.927
2-Aug-00	6:30 AM	7.9	7.4	6.5	14	95.46	8.5	0.928
2-Aug-00	7:00 AM	7.1	7.1	7.2	13.8	95.82	9.8	0.927
2-Aug-00	7:30 AM	7.6	7	7.2	13.8	96.17	10.4	0.927
2-Aug-00	8:00 AM	9.5	8.4	7.7	13.5	96.63	13	0.927
2-Aug-00	8:30 AM	38.9	15.7	7.7	13.5	97.75	13.7	0.927
2-Aug-00	9:00 AM	4	7.1	11.4	13.4	98.1	18.3	0.927
2-Aug-00	9:30 AM	6.2	5.8	11.4	13.4	98.35	18.4	0.928
2-Aug-00	10:00 AM	4.5	5	5.4	13.2	98.52	18.2	0.928
2-Aug-00	10:30 AM	6	5.7	5.4	13.2	98.76	17	0.928
2-Aug-00	11:00 AM	6	6.9	6.3	13	99.1	16.9	0.928
2-Aug-00	11:30 AM	6.5	6.6	6.3	13	99.41	16.7	0.928
2-Aug-00	12:00 PM	8	8.4	7.5	12.8	99.88	16.3	0.927
2-Aug-00	12:30 PM	4.3	5.1	7.5	12.8	100.06	17.4	0.927
2-Aug-00	1:00 PM	6	5.7	5.4	12	100.3	16.2	0.927
2-Aug-00	1:30 PM	5.7	5.4	5.4	12	100.51	16.2	0.927
2-Aug-00	2:00 PM	6.8	6.3	5.8	10.3	100.79	17.8	0.928
2-Aug-00	2:30 PM	5.1	5.2	5.8	10.3	100.98	20.6	0.928
2-Aug-00	3:00 PM	3.8	4.4	4.8	9.5	101.1	26.6	0.928
2-Aug-00	3:30 PM	5.4	5.2	4.8	9.5	101.3	24.5	0.928
2-Aug-00	4:00 PM	7.6	7.7	6.5	8.6	101.71	22.9	0.928
2-Aug-00	4:30 PM	8.4	7.8	6.5	8.6	102.13	21.7	0.928
2-Aug-00	5:00 PM	10.5	9.3	8.6	8.2	102.69	19.1	0.928

Date	Time							
2-Aug-00	5:30 PM	9.1	9.6	8.6	8.2	103.25	20	0.928
2-Aug-00	6:00 PM	6.9	7.5	8.5	8	103.65	18.8	0.927
2-Aug-00	6:30 PM	7.4	6.8	8.5	8	103.98	18.8	0.927
2-Aug-00	7:00 PM	6.5	7.7	7.2	7.6	104.38	18.6	0.927
2-Aug-00	7:30 PM	7.7	6.7	7.2	7.6	104.71	17.3	0.927
2-Aug-00	8:00 PM	8.4	8.3	7.5	7.2	105.17	16.9	0.928
2-Aug-00	8:30 PM	7.5	7.8	7.5	7.2	105.59	16.1	0.928
2-Aug-00	9:00 PM	6.4	6.9	7.4	7.1	105.94	15.1	0.928
2-Aug-00	9:30 PM	6.2	6.6	7.4	7.1	106.25	14.4	0.928
2-Aug-00	10:00 PM	5.9	6	6.3	7	106.51	13.6	0.928
2-Aug-00	10:30 PM	7.3	6.9	6.3	7	106.85	13.4	0.928
2-Aug-00	11:00 PM	8.2	7.6	7.3	7	107.26	12.6	0.928
2-Aug-00	11:30 PM	5.9	7	7.3	7	107.61	12.3	0.928
3-Aug-00	12:00 AM	6.6	6	6.5	6.9	107.87	11.7	0.928
3-Aug-00	12:30 AM	4.9	5.8	6.5	6.9	108.12	11.6	0.928
3-Aug-00	1:00 AM	5.4	5.7	5.7	6.9	108.34	11.2	0.928
3-Aug-00	1:30 AM	4.9	5.1	5.7	6.9	108.53	11.1	0.928
3-Aug-00	2:00 AM	6.7	6.1	5.6	6.8	108.81	11.2	0.928
3-Aug-00	2:30 AM	6.2	5.9	5.6	6.8	109.06	10.9	0.928
3-Aug-00	3:00 AM	4.9	5.3	5.6	6.8	109.26	10.5	0.928
3-Aug-00	3:30 AM	5.8	5.5	5.6	6.8	109.48	11.7	0.928
3-Aug-00	4:00 AM	4.9	5	5.2	6.8	109.65	12.2	0.928
3-Aug-00	4:30 AM	5	5.4	5.2	6.8	109.87	12.4	0.928
3-Aug-00	5:00 AM	5.4	4.5	5	6.7	109.99	12.1	0.928
3-Aug-00	5:30 AM	4.4	4.7	5	6.7	110.15	12.1	0.928
3-Aug-00	6:00 AM	5	5.1	4.9	6.6	110.33	11.9	0.928
3-Aug-00	6:30 AM	5.9	5	4.9	6.6	110.5	11.8	0.928
3-Aug-00	7:00 AM	5.1	5.1	5	6.5	110.68	12.6	0.928
3-Aug-00	7:30 AM	6.2	6	5	6.5	110.94	15.2	0.928
3-Aug-00	8:00 AM	6.1	6	6	6.5	111.21	17	0.928
3-Aug-00	8:30 AM	6.6	6.8	6	6.5	111.54	18.6	0.928
3-Aug-00	9:00 AM	6.5	7	6.9	6.3	111.89	19.5	0.928
3-Aug-00	9:30 AM	7.9	7.4	6.9	6.3	112.28	20.6	0.928
3-Aug-00	10:00 AM	9.4	8.8	8.1	6.4	112.78	19.1	0.929
3-Aug-00	10:30 AM	9.5	9.2	8.1	6.4	113.33	17.7	0.929
3-Aug-00	11:00 AM	8.7	8.8	9	6.5	113.83	19	0.929
3-Aug-00	11:30 AM	9.8	9.4	9	6.5	114.39	21.1	0.929
3-Aug-00	12:00 PM	15.8	12.5	11	6.7	115.22	21.8	0.929
3-Aug-00	12:30 PM	9.3	8.9	11	6.7	115.74	23.3	0.929
3-Aug-00	1:00 PM	9.9	9.6	9.2	6.8	116.31	24.8	0.929
3-Aug-00	1:30 PM	9.2	10.8	9.2	6.8	116.99	27.5	0.929
3-Aug-00	2:00 PM	11.3	9.4	10.1	7	117.55	23.5	0.929
3-Aug-00	2:30 PM	9.9	13.3	10.1	7	118.45	27.9	0.929
3-Aug-00	3:00 PM	14.3	14.6	13.9	7.4	119.46	28.7	0.929
3-Aug-00	3:30 PM	19.7	24.3	13.9	7.4	121.32	31.1	0.929
3-Aug-00	4:00 PM	8.4	9.8	17	7.8	121.91	31.3	0.929
3-Aug-00	4:30 PM	17.3	13.2	17	7.8	122.81	25	0.929
3-Aug-00	5:00 PM	11.2	13.2	13.2	8	123.69	27.9	0.928
3-Aug-00	5:30 PM	7.8	9.6	13.2	8	124.26	23.7	0.928
3-Aug-00	6:00 PM	9.9	9.5	9.5	8.1	124.83	21.7	0.928
3-Aug-00	6:30 PM	9.4	9.3	9.5	8.1	125.38	20.9	0.927
3-Aug-00	7:00 PM	7.2	7.6	8.4	8.1	125.78	20.8	0.927
3-Aug-00	7:30 PM	9.3	9.2	8.4	8.1	126.32	20.3	0.927
3-Aug-00	8:00 PM	8.7	9.7	9.4	8.2	126.91	20.5	0.927
3-Aug-00	8:30 PM	12	10.4	9.4	8.2	127.55	17.7	0.927
3-Aug-00	9:00 PM	12.5	12.4	11.4	8.3	128.37	16.3	0.927
3-Aug-00	9:30 PM	13.9	14.4	11.4	8.3	129.37	15.1	0.927
3-Aug-00	10:00 PM	12.5	12.3	13.3	8.6	130.17	13.6	0.927
3-Aug-00	10:30 PM	12.1	13	13.3	8.6	131.05	12.7	0.927
3-Aug-00	11:00 PM	10.3	10.4	11.7	8.8	131.7	12.9	0.927
3-Aug-00	11:30 PM	9.7	11.9	11.7	8.8	132.47	12	0.928
4-Aug-00	12:00 AM	8.9	8.9	10.4	9	132.99	11.6	0.927

206

4-Aug-00	12:30 AM	9.1	9	10.4	9	133.51	11.3	0.927
4-Aug-00	1:00 AM	7.8	8.7	8.8	9.1	134	11	0.927
4-Aug-00	1:30 AM	12.1	10.5	8.8	9.1	134.66	10.6	0.927
4-Aug-00	2:00 AM	12.5	13.2	11.8	9.4	135.55	10.4	0.926
4-Aug-00	2:30 AM	11.6	12.9	11.8	9.4	136.41	10.2	0.926
4-Aug-00	3:00 AM	11.1	11.5	12.2	9.7	137.16	9.8	0.926
4-Aug-00	3:30 AM	10.8	11.3	12.2	9.7	137.88	10.2	0.926
4-Aug-00	4:00 AM	10.6	11.2	11.2	9.9	138.6	10.3	0.926
4-Aug-00	4:30 AM	10.2	11.1	11.2	9.9	139.3	9.1	0.926
4-Aug-00	5:00 AM	8.8	9.9	10.5	10.1	139.91	8.7	0.926
4-Aug-00	5:30 AM	11.4	10.4	10.5	10.1	140.56	8.6	0.927
4-Aug-00	6:00 AM	9.3	9.4	9.9	10.3	141.11	8.9	0.926
4-Aug-00	6:30 AM	11.3	11	9.9	10.3	141.81	10	0.926
4-Aug-00	7:00 AM	10.7	10.7	10.8	10.6	142.48	10.6	0.926
4-Aug-00	7:30 AM	11.7	12.1	10.8	10.6	143.27	12.4	0.927
4-Aug-00	8:00 AM	9.7	9.5	10.8	10.8	143.84	15.2	0.927
4-Aug-00	8:30 AM	8.5	9.8	10.8	10.8	144.43	18	0.927
4-Aug-00	9:00 AM	9.4	9.7	9.7	10.9	145.01	19.9	0.927
4-Aug-00	9:30 AM	9	8.8	9.7	10.9	145.52	22.4	0.928
4-Aug-00	10:00 AM	10.2	10.4	9.6	11	146.18	23.6	0.928
4-Aug-00	10:30 AM	10.2	11.4	9.6	11	146.9	24.5	0.928
4-Aug-00	11:00 AM	15.4	13.5	12.4	11.1	147.82	26.5	0.928
4-Aug-00	11:30 AM	15.5	15.5	12.4	11.1	148.91	25.8	0.928
4-Aug-00	12:00 PM	10.4	12.6	14	11.2	149.75	25.8	0.927
4-Aug-00	12:30 PM	7.8	8.8	14	11.2	150.25	30.1	0.927
4-Aug-00	1:00 PM	10.1	8.6	8.7	11.2	150.74	29.4	0.928
4-Aug-00	1:30 PM	10.4	11.5	8.7	11.2	151.49	30.1	0.928
4-Aug-00	2:00 PM	10.7	10.5	11	11.2	152.14	32.5	0.928
4-Aug-00	2:30 PM	11.7	13	11	11.2	153.01	34.3	0.927
4-Aug-00	3:00 PM	16.9	14.1	13.6	11.2	153.99	36.5	0.927
4-Aug-00	3:30 PM	15.8	16.2	13.6	11.2	155.14	33.8	0.927
4-Aug-00	4:00 PM	14.7	15.4	15.8	11.2	156.22	37.4	0.927
4-Aug-00	4:30 PM	18	17.6	15.8	11.2	157.5	35.2	0.927
4-Aug-00	5:00 PM	20	20.7	19.2	11.4	159.05	32.8	0.927
4-Aug-00	5:30 PM	15.5	18.3	19.2	11.4	160.38	29.1	0.926
4-Aug-00	6:00 PM	22.4	17.9	18.1	11.8	161.68	24.6	0.926
4-Aug-00	6:30 PM	20.1	20.7	18.1	11.8	163.23	23.1	0.925
4-Aug-00	7:00 PM	19.3	19.9	20.3	12.3	164.71	22.6	0.925
4-Aug-00	7:30 PM	19.4	20.2	20.3	12.3	166.21	21.2	0.925
4-Aug-00	8:00 PM	19	17.7	19	12.7	167.5	20.8	0.925
4-Aug-00	8:30 PM	21.2	21.4	19	12.7	169.11	19.1	0.925
4-Aug-00	9:00 PM	26.6	27.1	24.3	13.2	171.23	17.4	0.925
4-Aug-00	9:30 PM	28.8	30.1	24.3	13.2	173.6	16.3	0.925
4-Aug-00	10:00 PM	42.2	40.7	35.4	14.1	176.89	15.6	0.925
4-Aug-00	10:30 PM	27.5	32.8	35.4	14.1	179.49	14.9	0.925
4-Aug-00	11:00 PM	24.4	25.2	29	14.9	181.43	15.2	0.925
4-Aug-00	11:30 PM	19.2	22.5	29	14.9	183.13	14.7	0.924
5-Aug-00	12:00 AM	17.4	17.8	20.1	15.3	184.42	14.7	0.924
5-Aug-00	12:30 AM	16.7	16.3	20.1	15.3	185.58	13.5	0.924
5-Aug-00	1:00 AM	20.3	19.1	17.7	15.6	186.99	12.6	0.924
5-Aug-00	1:30 AM	20.7	21.9	17.7	15.6	188.65	12.3	0.924
5-Aug-00	2:00 AM	19.1	20.6	21.3	16	190.18	12	0.924
5-Aug-00	2:30 AM	16.7	18.2	21.3	16	191.5	11.6	0.924
5-Aug-00	3:00 AM	16.6	17.3	17.7	16.3	192.75	11.1	0.923
5-Aug-00	3:30 AM	15.7	16	17.7	16.3	193.89	11	0.923
5-Aug-00	4:00 AM	15	15.5	15.8	16.4	194.98	11.2	0.923
5-Aug-00	4:30 AM	15.8	15.6	15.8	16.4	196.09	11.7	0.923
5-Aug-00	5:00 AM	11.7	13	14.3	16.6	196.96	12.4	0.923
5-Aug-00	5:30 AM	10.9	12	14.3	16.6	197.74	12.9	0.923
5-Aug-00	6:00 AM	10.3	11.2	11.6	16.7	198.46	12.5	0.923
5-Aug-00	6:30 AM	10.9	11.5	11.6	16.7	199.2	12.5	0.923
5-Aug-00	7:00 AM	11.6	10.9	11.2	16.7	199.88	13.4	0.923

207

5-Aug-00	7:30 AM	9.7	10.8	11.2	16.7	200.56	15.8	0.923
5-Aug-00	8:00 AM	10.4	10.9	10.8	16.7	201.25	17.4	0.923
5-Aug-00	8:30 AM	9.9	11.2	10.8	16.7	201.96	20.3	0.924
5-Aug-00	9:00 AM	11.2	10.5	10.8	16.7	202.62	19.8	0.924
5-Aug-00	9:30 AM	10.4	10.2	10.8	16.7	203.25	23.1	0.924
5-Aug-00	10:00 AM	9.3	10.6	10.4	16.8	203.91	22.3	0.924
5-Aug-00	10:30 AM	10	10.7	10.4	16.8	204.58	25.1	0.924
5-Aug-00	11:00 AM	10.9	10.4	10.5	16.7	205.23	28.5	0.924
5-Aug-00	11:30 AM	10.7	11.7	10.5	16.7	205.99	27.8	0.925
5-Aug-00	12:00 PM	14	13.9	12.8	16.6	206.94	30.3	0.925
5-Aug-00	12:30 PM	9.8	0	12.8	16.6	206.3	30.8	0.925
5-Aug-00	1:00 PM	15.7	13.6	4.6	16.5	207.23	32.4	0.925
5-Aug-00	1:30 PM	10.4	11.2	4.6	16.5	207.94	32	0.925
5-Aug-00	2:00 PM	12.6	14.8	13	16.5	208.97	33.8	0.925
5-Aug-00	2:30 PM	17.9	18.6	13	16.5	210.34	33.9	0.925
5-Aug-00	3:00 PM	10.2	14.6	16.6	16.7	211.34	35.2	0.925
5-Aug-00	3:30 PM	14.9	13.3	16.6	16.7	212.25	36.2	0.925
5-Aug-00	4:00 PM	7.4	10.5	11.9	16.5	212.89	34.3	0.925
5-Aug-00	4:30 PM	12.1	11.7	11.9	16.5	213.66	36.2	0.924
5-Aug-00	5:00 PM	11.6	13.8	12.8	16.2	214.6	33.8	0.923
5-Aug-00	5:30 PM	16.5	13.3	12.8	16.2	215.5	29.2	0.923
5-Aug-00	6:00 PM	14.2	14.4	13.8	16.1	216.5	27	0.923
5-Aug-00	6:30 PM	16	14.3	13.8	16.1	217.49	25.9	0.923
5-Aug-00	7:00 PM	15.5	15.8	15.1	15.8	218.61	25.2	0.922
5-Aug-00	7:30 PM	16	16.5	15.1	15.8	219.78	25	0.922
5-Aug-00	8:00 PM	17.1	16.4	16.4	15.7	220.95	22.7	0.922
5-Aug-00	8:30 PM	28.6	22.8	16.4	15.7	222.69	22.1	0.922
5-Aug-00	9:00 PM	34.2	27.1	25	15.8	224.81	21	0.922
5-Aug-00	9:30 PM	26.9	35	25	15.8	227.59	19.2	0.922
5-Aug-00	10:00 PM	26.2	27	31	15.6	229.69	18.9	0.921
5-Aug-00	10:30 PM	22.6	22	31	15.6	231.35	18.2	0.921
5-Aug-00	11:00 PM	22.6	24	23	15.3	233.19	17.6	0.921
5-Aug-00	11:30 PM	20.3	19.7	23	15.3	234.64	18	0.921
6-Aug-00	12:00 AM	23.5	23.5	21.6	15.4	236.43	16.6	0.921
6-Aug-00	12:30 AM	23.9	25.5	21.6	15.4	238.4	16.5	0.92
6-Aug-00	1:00 AM	25.5	25.7	25.6	15.7	240.38	16.2	0.92
6-Aug-00	1:30 AM	32.4	28.5	25.6	15.7	242.63	16.9	0.921
6-Aug-00	2:00 AM	20.3	24.7	26.6	16	244.52	15.9	0.92
6-Aug-00	2:30 AM	17.7	19.2	26.6	16	245.92	14.2	0.922
6-Aug-00	3:00 AM	2.2	0.6	9.9	15.6	245.71	13.9	0.92
6-Aug-00	3:30 AM	3.5	2.8	9.9	15.6	245.69	13.8	0.919
6-Aug-00	4:00 AM	4.8	5.9	4.3	15.2	245.95	14.8	0.92
6-Aug-00	4:30 AM	0	3	4.3	15.2	245.94	14.2	0.92
6-Aug-00	5:00 AM	4.4	3.8	3.4	14.7	246.02	13.5	0.919
6-Aug-00	5:30 AM	6	6.3	3.4	14.7	246.31	12.2	0.919
6-Aug-00	6:00 AM	7.5	7.3	6.8	14.5	246.68	12.3	0.92
6-Aug-00	6:30 AM	4.5	5.5	6.8	14.5	246.9	12.6	0.919
6-Aug-00	7:00 AM	7.2	5.7	5.6	14.3	247.14	12.7	0.919
6-Aug-00	7:30 AM	7.8	7.8	5.6	14.3	247.56	16	0.919
6-Aug-00	8:00 AM	8.7	7.4	7.6	14.1	247.95	18.2	0.919
6-Aug-00	8:30 AM	4.4	7.7	7.6	14.1	248.35	20.6	0.919
6-Aug-00	9:00 AM	9.1	9.1	8.4	14	248.9	22.6	0.919
6-Aug-00	9:30 AM	8	8.1	8.4	14	249.34	23.7	0.92
6-Aug-00	10:00 AM	8.3	10.8	9.5	14	250.02	24.6	0.92
6-Aug-00	10:30 AM	12.1	11.1	9.5	14	250.73	24.5	0.92
6-Aug-00	11:00 AM	17.8	15.7	13.4	14.1	251.85	28.3	0.921
6-Aug-00	11:30 AM	13	15.4	13.4	14.1	252.92	27.4	0.92
6-Aug-00	12:00 PM	12.4	11.7	13.5	14.1	253.68	26.9	0.921
6-Aug-00	12:30 PM	3.9	15.2	13.5	14.1	254.73	21.7	0.922
6-Aug-00	1:00 PM	13	20.3	17.7	14.7	256.26	24.5	0.921
6-Aug-00	1:30 PM	9.1	9.9	17.7	14.7	256.86	21.6	0.92
6-Aug-00	2:00 PM	15.3	15.5	12.7	14.7	257.97	23.2	0.921

6-Aug-00	2:30 PM	12.1	11.9	12.7	14.7	258.74	25.1	0.922
6-Aug-00	3:00 PM	11.5	11.7	11.8	14.5	259.5	22.3	0.922
6-Aug-00	3:30 PM	8.7	9.3	11.8	14.5	260.05	20.3	0.923
6-Aug-00	4:00 PM	9.9	8.8	9.1	14.4	260.56	19.1	0.923
6-Aug-00	4:30 PM	6.1	9.2	9.1	14.4	261.1	16.7	0.922
6-Aug-00	5:00 PM	7.1	6.2	7.7	14.2	261.38	19.3	0.922
6-Aug-00	5:30 PM	6.8	6.8	7.7	14.2	261.71	19.1	0.922
6-Aug-00	6:00 PM	7.7	8.4	7.6	13.9	262.18	18.8	0.922
6-Aug-00	6:30 PM	1.1	5.5	7.6	13.9	262.39	18.4	0.923
6-Aug-00	7:00 PM	4.3	3.9	4.7	13.5	262.47	18.4	0.922
6-Aug-00	7:30 PM	3.1	3.6	4.7	13.5	262.52	17.7	0.922
6-Aug-00	8:00 PM	6.3	5.8	4.7	13	262.76	17	0.922
6-Aug-00	8:30 PM	6.4	7.1	4.7	13	263.13	16.3	0.922
6-Aug-00	9:00 PM	6.6	6.1	6.6	12.2	263.4	15.7	0.922
6-Aug-00	9:30 PM	6.3	7.4	6.6	12.2	263.79	15.3	0.922
6-Aug-00	10:00 PM	6.4	6.6	7	11.2	264.1	14.8	0.923
6-Aug-00	10:30 PM	6.7	7	7	11.2	264.45	14.4	0.923
6-Aug-00	11:00 PM	6.8	6.8	6.9	10.5	264.78	14.2	0.923
6-Aug-00	11:30 PM	6.8	6.9	6.9	10.5	265.13	14	0.923
7-Aug-00	12:00 AM	6.8	7.5	7.2	9.9	265.52	13.9	0.923
7-Aug-00	12:30 AM	5.7	6.4	7.2	9.9	265.82	13.8	0.923
7-Aug-00	1:00 AM	5.2	6	6.2	9.1	266.08	13.7	0.923
7-Aug-00	1:30 AM	3.9	4.2	6.2	9.1	266.18	13.2	0.923
7-Aug-00	2:00 AM	3.8	3.6	3.9	8.2	266.24	13.1	0.923
7-Aug-00	2:30 AM	4.1	4.1	3.9	8.2	266.33	12.6	0.923
7-Aug-00	3:00 AM	4	4.1	4.1	7.9	266.43	11.6	0.923
7-Aug-00	3:30 AM	4.4	4.4	4.1	7.9	266.55	11.2	0.922
7-Aug-00	4:00 AM	4.8	5.3	4.8	8	266.75	10.9	0.922
7-Aug-00	4:30 AM	4.8	5.4	4.8	8	266.96	10.7	0.922
7-Aug-00	5:00 AM	5.2	6.5	5.9	8.1	267.26	10.4	0.922
7-Aug-00	5:30 AM	7.2	7.2	5.9	8.1	267.64	11	0.922
7-Aug-00	6:00 AM	5	5	6.1	8.1	267.81	9.9	0.922
7-Aug-00	6:30 AM	8.1	7.2	6.1	8.1	268.17	10.6	0.922
7-Aug-00	7:00 AM	6.8	7.3	7.2	8.1	268.55	11.2	0.922
7-Aug-00	7:30 AM	6.6	6.7	7.2	8.1	268.88	11.8	0.922
7-Aug-00	8:00 AM	7.1	8	7.4	8.1	269.31	13.4	0.922
7-Aug-00	8:30 AM	6.7	7.1	7.4	8.1	269.67	14	0.922
7-Aug-00	9:00 AM	6.6	6.9	7.2	8.1	269.71	14.6	0.922
7-Aug-00	9:30 AM	6.5	6.7	7	8.1	269.8	17.4	0.922
7-Aug-00	10:00 AM	4.9	6.5	6.9	8.1	270.11	16.1	0.922
7-Aug-00	10:30 AM	8.7	6.8	6.7	8.1	270.45	18.6	0.922
7-Aug-00	11:00 AM	6.6	6.2	6.5	8.1	270.73	19.5	0.922
7-Aug-00	11:30 AM	5.7	5	6.5	8.1	270.9	21.1	0.922
7-Aug-00	12:00 PM	5.7	4.6	4.8	8.1	271.02	24	0.922
7-Aug-00	12:30 PM	4.2	7	4.8	8.1	271.39	22.3	0.922
7-Aug-00	1:00 PM	0	2.2	4.6	8.1	271.31	26.1	0.922
7-Aug-00	1:30 PM	4.3	3	4.6	8	271.32	27.3	0.922
7-Aug-00	2:00 PM	3.1	5.1	4	8	271.5	26	0.922
7-Aug-00	2:30 PM	4	4.9	4	8	271.66	29.7	0.922
7-Aug-00	3:00 PM	2.9	3.6	4.2	8	271.71	31.4	0.922
7-Aug-00	3:30 PM	8.8	7.2	4.2	8	272.08	26.3	0.922
7-Aug-00	4:00 PM	11.8	25.7	16.4	8.4	274.07	24.6	0.922
7-Aug-00	4:30 PM	8.2	10.9	16.4	8.4	274.75	24.2	0.921
7-Aug-00	5:00 PM	14.4	13.1	12	8.4	275.64	22.8	0.921
7-Aug-00	5:30 PM	12.5	12.6	12	8.4	276.48	22.5	0.922
7-Aug-00	6:00 PM	11.5	14	13.3	8.4	277.43	17.8	0.922
7-Aug-00	6:30 PM	13	13.5	13.3	8.4	278.35	16.4	0.921
7-Aug-00	7:00 PM	10.9	10.9	12.2	8.5	279.05	15	0.922
7-Aug-00	7:30 PM	3.5	6.6	12.2	8.4	279.35	14.6	0.922
7-Aug-00	8:00 PM	7.4	6.5	6.5	8.3	279.66	14.3	0.921
7-Aug-00	8:30 PM	5.5	5.6	6.5	8.2	279.88	15	0.922
7-Aug-00	9:00 PM	8.9	8.3	7	8.1	280.35	13.3	0.922

7-Aug-00	9:30 PM	8.7	8.7	7	8	280.84	12.1	0.922
7-Aug-00	10:00 PM	14.5	9.4	9	8	281.42	10.9	0.923
7-Aug-00	10:30 PM	6.5	10.1	9	8	282.02	10.2	0.923
7-Aug-00	11:00 PM	8.4	7.8	8.9	8	282.44	10.7	0.923
7-Aug-00	11:30 PM	7.3	6.9	8.9	7.9	282.78	10	0.923
8-Aug-00	12:00 AM	9.1	9.6	8.3	7.9	283.36	10.5	0.922
8-Aug-00	12:30 AM	10.5	11.6	8.3	7.9	284.12	10.6	0.923
8-Aug-00	1:00 AM	7	7.8	9.7	7.9	284.54	10.3	0.923
8-Aug-00	1:30 AM	6.3	6.6	9.7	7.9	284.85	10.2	0.923
8-Aug-00	2:00 AM	6.6	6	6.3	7.9	285.11	10	0.923
8-Aug-00	2:30 AM	5.5	5.4	6.3	7.9	285.32	9.5	0.923
8-Aug-00	3:00 AM	7	6.6	6	7.9	285.64	9.3	0.923
8-Aug-00	3:30 AM	6	6	6	7.9	285.9	8.7	0.923
8-Aug-00	4:00 AM	6.5	6.8	6.4	7.9	286.24	9.2	0.923
8-Aug-00	4:30 AM	6	6.2	6.4	7.8	286.51	8.7	0.923
8-Aug-00	5:00 AM	6	6.6	6.4	7.8	286.83	8.1	0.923
8-Aug-00	5:30 AM	7.1	6.9	6.4	7.8	287.17	7.7	0.923
8-Aug-00	6:00 AM	9.1	8.3	7.6	7.8	287.63	7.8	0.923
8-Aug-00	6:30 AM	9.4	8.3	7.6	7.9	288.09	8.2	0.923
8-Aug-00	7:00 AM	7.5	7.4	7.8	7.9	288.48	9.1	0.923
8-Aug-00	7:30 AM	12.1	10.7	7.8	7.9	289.15	11.2	0.923
8-Aug-00	8:00 AM	6.7	6.1	8.4	8	289.41	13.3	0.924
8-Aug-00	8:30 AM	7	6.4	8.4	8	289.71	17.1	0.924
8-Aug-00	9:00 AM	5.6	4.2	5.3	7.8	289.81	17.5	0.924
8-Aug-00	9:30 AM	2.9	4.3	5.3	7.8	289.92	19.2	0.924
8-Aug-00	10:00 AM	5.6	5	4.6	7.8	290.1	20.5	0.925
8-Aug-00	10:30 AM	4.4	5	4.6	7.8	290.27	21.8	0.925
8-Aug-00	11:00 AM	4.7	5.3	5.1	7.7	290.47	22.9	0.925
8-Aug-00	11:30 AM	5.8	6.3	5.1	7.7	290.75	25.2	0.926
8-Aug-00	12:00 PM	6.7	6.2	6.2	7.8	291.03	26.5	0.926
8-Aug-00	12:30 PM	13.4	4.5	6.2	7.8	291.17	28	0.925
8-Aug-00	1:00 PM	4.5	9.6	7.1	7.9	291.74	26.1	0.926
8-Aug-00	1:30 PM	5.8	6	7.1	7.9	292.01	29.4	0.926
8-Aug-00	2:00 PM	6.6	6.1	6.1	8	292.28	27.7	0.926
8-Aug-00	2:30 PM	5.4	6.6	6.1	8	292.59	28.9	0.926
8-Aug-00	3:00 PM	6	6.9	6.8	8.1	292.93	29.1	0.926
8-Aug-00	3:30 PM	7.4	7.5	6.8	8.1	293.33	32.3	0.926
8-Aug-00	4:00 PM	8	7.6	7.6	7.7	293.73	33.4	0.926
8-Aug-00	4:30 PM	9.9	10.1	7.6	7.7	294.36	33.5	0.926
8-Aug-00	5:00 PM	10.4	10	10.1	7.6	294.97	23.2	0.926
8-Aug-00	5:30 PM	15.3	13.5	10.1	7.6	295.89	21.8	0.926
8-Aug-00	6:00 PM	12.8	11.8	12.7	7.6	296.66	21.9	0.926
8-Aug-00	6:30 PM	8.8	11.2	12.7	7.6	297.37	20.2	0.926
8-Aug-00	7:00 PM	13.9	12.8	12	7.6	298.23	19.3	0.926
8-Aug-00	7:30 PM	10.2	10.5	12	7.6	298.88	18	0.926
8-Aug-00	8:00 PM	10.9	11.7	11.1	7.8	299.64	17.7	0.926
8-Aug-00	8:30 PM	13	11.8	11.1	7.8	300.41	16.7	0.926
8-Aug-00	9:00 PM	13	13.7	12.7	8	301.34	16	0.926
8-Aug-00	9:30 PM	16.5	15.5	12.7	8	302.44	15.7	0.927
8-Aug-00	10:00 PM	11.8	12.5	14	8.2	303.26	14.6	0.927
8-Aug-00	10:30 PM	7.7	8.4	14	8.2	303.73	13.9	0.927
8-Aug-00	11:00 PM	8.7	8.7	8.5	8.2	304.23	13.1	0.927
8-Aug-00	11:30 PM	10.3	10.5	8.5	8.2	304.88	12.6	0.927
9-Aug-00	12:00 AM	10.3	9.1	9.8	8.3	305.41	12.1	0.928
9-Aug-00	12:30 AM	7.2	4.7	9.8	8.3	305.56	11.4	0.927
9-Aug-00	1:00 AM	2.7	5.2	5	8.1	305.75	11.2	0.927
9-Aug-00	1:30 AM	5.6	3.6	5	8.1	305.8	11	0.927
9-Aug-00	2:00 AM	3.7	3.7	3.7	7.9	305.86	10.7	0.927
9-Aug-00	2:30 AM	4.2	3.1	3.7	7.9	305.88	10.7	0.927
9-Aug-00	3:00 AM	5.5	5.6	4.3	7.9	306.1	10.7	0.927
9-Aug-00	3:30 AM	4.5	4.6	4.3	7.9	306.24	10.7	0.927
9-Aug-00	4:00 AM	5.2	6.3	5.4	7.8	306.52	10.9	0.928

9-Aug-00	4:30 AM	3.9	4.2	5.4	7.8	306.63	10.7	0.927
9-Aug-00	5:00 AM	4.8	4.7	4.4	7.8	306.77	10.6	0.927
9-Aug-00	5:30 AM	4.8	5.3	4.4	7.8	306.97	10.7	0.927
9-Aug-00	6:00 AM	5.5	5.2	5.3	7.7	307.17	10.6	0.927
9-Aug-00	6:30 AM	7.4	7	5.3	7.7	307.52	10.3	0.927
9-Aug-00	7:00 AM	8.5	8	7.5	7.6	307.96	9.7	0.927
9-Aug-00	7:30 AM	10.7	9.2	7.5	7.6	308.5	11.9	0.927
9-Aug-00	8:00 AM	8.6	8.9	9	7.7	309.01	13.5	0.927
9-Aug-00	8:30 AM	8.3	9.3	9	7.7	309.57	14.7	0.926
9-Aug-00	9:00 AM	9.4	7.9	8.6	7.8	309.99	16.1	0.926
9-Aug-00	9:30 AM	5.1	7.6	8.6	7.8	310.39	17.2	0.926
9-Aug-00	10:00 AM	6.1	6.9	7.2	7.9	310.72	19	0.926
9-Aug-00	10:30 AM	10.5	9.7	7.2	7.9	311.31	19.3	0.926
9-Aug-00	11:00 AM	9.4	10.3	10	8.1	311.95	19.5	0.926
9-Aug-00	11:30 AM	10.2	8.8	10	8.1	312.46	20.1	0.925
9-Aug-00	12:00 PM	8.9	9	8.9	8.2	312.99	20.1	0.925
9-Aug-00	12:30 PM	11.2	9.9	8.9	8.2	313.6	20.9	0.925
9-Aug-00	1:00 PM	9.2	9.7	9.8	8.3	314.18	23.5	0.924
9-Aug-00	1:30 PM	11.1	11	9.8	8.3	314.88	24.5	0.924
9-Aug-00	2:00 PM	23	27.9	19.4	8.9	317.06	24.3	0.924
9-Aug-00	2:30 PM	13.8	18.5	19.4	8.9	318.41	21.9	0.924
9-Aug-00	3:00 PM	13.4	14.4	16.5	9.3	319.41	22.7	0.924
9-Aug-00	3:30 PM	14.1	15.2	16.5	9.3	320.47	21.5	0.923
9-Aug-00	4:00 PM	15.3	15.9	15.5	9.6	321.6	26.4	0.923
9-Aug-00	4:30 PM	15.2	14.6	15.5	9.6	322.61	25.5	0.923
9-Aug-00	5:00 PM	15.9	16.9	15.8	9.9	323.83	25.6	0.922
9-Aug-00	5:30 PM	15.9	15.3	15.8	9.9	324.91	22.6	0.922
9-Aug-00	6:00 PM	15.3	15	15.1	10	325.96	21.9	0.921
9-Aug-00	6:30 PM	15.5	15.4	15.1	10	327.03	20.6	0.921
9-Aug-00	7:00 PM	14.9	14.5	14.9	10.1	328.03	19.3	0.921
9-Aug-00	7:30 PM	15.6	15	14.9	10.1	329.09	19	0.921
9-Aug-00	8:00 PM	16.6	15.5	15.2	10.3	330.17	18.1	0.921
9-Aug-00	8:30 PM	17.3	16.7	15.2	10.3	331.37	17.3	0.921
9-Aug-00	9:00 PM	14.1	14.5	15.6	10.4	332.37	16.3	0.921
9-Aug-00	9:30 PM	13.5	12.4	15.6	10.4	333.2	15.6	0.921
9-Aug-00	10:00 PM	12.6	12.3	12.4	10.3	334.01	15.2	0.921
9-Aug-00	10:30 PM	9.8	10.5	12.4	10.3	334.67	14.4	0.921
9-Aug-00	11:00 PM	13.5	11.4	11	10.4	335.4	14	0.921
9-Aug-00	11:30 PM	11.6	12.8	11	10.4	336.25	13.3	0.922
10-Aug-00	12:00 AM	13.1	13.7	13.3	10.6	337.19	12.6	0.922
10-Aug-00	12:30 AM	12.6	10.9	13.3	10.6	337.89	12.5	0.923
10-Aug-00	1:00 AM	8.9	10.5	10.7	10.8	338.54	13.2	0.923
10-Aug-00	1:30 AM	8.6	7.4	10.7	10.8	338.92	12.9	0.923
10-Aug-00	2:00 AM	7.9	7.6	7.5	11	339.32	12.6	0.923
10-Aug-00	2:30 AM	10.6	10.4	7.5	11	339.96	12.3	0.923
10-Aug-00	3:00 AM	10.7	10.9	10.6	11.2	340.65	11.4	0.924
10-Aug-00	3:30 AM	7	6.5	10.6	11.2	340.95	10.8	0.924
10-Aug-00	4:00 AM	5.9	6.1	6.3	11.3	341.22	11.1	0.924
10-Aug-00	4:30 AM	5.9	5.5	6.3	11.3	341.45	11.3	0.924
10-Aug-00	5:00 AM	4.8	5.2	5.4	11.3	341.64	11.3	0.924
10-Aug-00	5:30 AM	5.1	5.5	5.4	11.3	341.85	11.3	0.925
10-Aug-00	6:00 AM	7.1	5.6	5.5	11.3	342.08	10.9	0.925
10-Aug-00	6:30 AM	6	6.8	5.5	11.3	342.41	11.4	0.925
10-Aug-00	7:00 AM	6.3	5.7	6.3	11.3	342.65	11.7	0.925
10-Aug-00	7:30 AM	6.3	6.3	6.3	11.3	342.94	11.9	0.925
10-Aug-00	8:00 AM	6.2	5.9	6.1	11.1	343.2	12.5	0.926
10-Aug-00	8:30 AM	5.5	5.3	6.1	11.1	343.39	13.5	0.926
10-Aug-00	9:00 AM	6.8	5.7	5.5	11	343.63	13.9	0.926
10-Aug-00	9:30 AM	4.5	5	5.5	11	343.8	14.7	0.926
10-Aug-00	10:00 AM	3.6	5	5	10.9	343.97	16.5	0.927
10-Aug-00	10:30 AM	5.1	4.7	5	10.9	344.13	17.5	0.927
10-Aug-00	11:00 AM	6.3	6.3	5.5	10.7	344.41	17.7	0.927

10-Aug-00	11:30 AM	4.1	4.4	5.5	10.7	344.53	20.3	0.927
10-Aug-00	12:00 PM	4.5	6.9	5.6	10.6	344.87	25	0.927
10-Aug-00	12:30 PM	7.9	6.1	5.6	10.6	345.14	26	0.927
10-Aug-00	1:00 PM	6.3	6	6	10.4	345.4	26.3	0.928
10-Aug-00	1:30 PM	4.1	7.4	6	10.4	345.78	27.3	0.927
10-Aug-00	2:00 PM	7.5	6.8	7.1	9.9	346.12	26	0.927
10-Aug-00	2:30 PM	9.6	13.2	7.1	9.9	347	25.9	0.928
10-Aug-00	3:00 PM	9.6	10.1	11.6	9.7	347.63	26.7	0.927
10-Aug-00	3:30 PM	9.5	9.2	11.6	9.7	348.17	28.6	0.928
10-Aug-00	4:00 PM	7.7	6.3	7.7	9.4	348.46	29.7	0.928
10-Aug-00	4:30 PM	6.2	9.4	7.7	9.4	349.02	29.2	0.927
10-Aug-00	5:00 PM	13.8	11.9	10.6	9.2	349.8	25.4	0.927
10-Aug-00	5:30 PM	13.1	14.8	10.6	9.2	350.83	21.5	0.926
10-Aug-00	6:00 PM	17.3	18.2	16.5	9.2	352.15	21.7	0.926
10-Aug-00	6:30 PM	19.1	18.3	16.5	9.2	353.49	20.2	0.926
10-Aug-00	7:00 PM	15.5	15.2	16.8	9.3	354.56	19	0.926
10-Aug-00	7:30 PM	11.2	12.5	16.8	9.3	355.38	18.1	0.926
10-Aug-00	8:00 PM	13.2	13.5	13	9.2	356.3	17.2	0.926
10-Aug-00	8:30 PM	17.1	16.3	13	9.2	357.47	16.9	0.926
10-Aug-00	9:00 PM	21.9	21.2	18.8	9.4	359.06	16.3	0.926
10-Aug-00	9:30 PM	17.4	22.5	18.8	9.4	360.76	14.6	0.926
10-Aug-00	10:00 PM	12.6	11.7	17.1	9.6	361.53	14.8	0.926
10-Aug-00	10:30 PM	13	13.2	17.1	9.6	362.42	14.9	0.926
10-Aug-00	11:00 PM	8.4	9.1	11.2	9.6	362.95	14.6	0.926
10-Aug-00	11:30 PM	6.7	9.9	11.2	9.6	363.55	14.2	0.926
11-Aug-00	12:00 AM	7.5	7.6	8.7	9.4	363.95	13.6	0.926
11-Aug-00	12:30 AM	8.6	7.7	8.7	9.4	364.36	13.3	0.926
11-Aug-00	1:00 AM	11.2	10.5	9.1	9.3	365.01	13	0.926
11-Aug-00	1:30 AM	9.1	9.5	9.1	9.3	365.58	13.2	0.926
11-Aug-00	2:00 AM	13	10.3	9.9	9.4	366.22	13.4	0.927
11-Aug-00	2:30 AM	7.3	6.9	9.9	9.4	366.56	13.1	0.926
11-Aug-00	3:00 AM	4.9	5.9	6.4	9.2	366.81	12.6	0.926
11-Aug-00	3:30 AM	7.3	7.6	6.4	9.2	367.22	12.4	0.925
11-Aug-00	4:00 AM	6.2	5.5	6.6	9.3	367.44	12.3	0.924
11-Aug-00	4:30 AM	7.6	8	6.6	9.3	367.88	12.5	0.925
11-Aug-00	5:00 AM	5.1	5.8	6.9	9.3	368.12	12.3	0.925
11-Aug-00	5:30 AM	6.6	6.4	6.9	9.3	368.42	11.7	0.925
11-Aug-00	6:00 AM	8.7	8.2	7.3	9.4	368.87	12.2	0.925
11-Aug-00	6:30 AM	12.5	11.6	7.3	9.4	369.62	12.6	0.926
11-Aug-00	7:00 AM	9.2	9.2	10.4	9.6	370.16	12.2	0.926
11-Aug-00	7:30 AM	7.1	8.9	10.4	9.6	370.68	11.5	0.925
11-Aug-00	8:00 AM	4.6	5.5	7.2	9.6	370.89	11.7	0.925
11-Aug-00	8:30 AM	6.9	6.8	7.2	9.6	371.22	12.1	0.924
11-Aug-00	9:00 AM	8.4	8.9	7.8	9.7	371.73	12.4	0.924
11-Aug-00	9:30 AM	10.7	8.1	7.8	9.7	372.18	13.7	0.924
11-Aug-00	10:00 AM	8.4	7.7	7.9	9.8	372.59	14.2	0.925
11-Aug-00	10:30 AM	7.8	7.5	7.9	9.8	372.98	15.1	0.925
11-Aug-00	11:00 AM	7.1	8.1	7.8	9.9	373.43	15.5	0.925
11-Aug-00	11:30 AM	13.7	13	7.8	9.9	374.32	15.7	0.925
11-Aug-00	12:00 PM	15.3	17.1	15.1	10.3	375.55	15.5	0.925
11-Aug-00	12:30 PM	13.9	14	15.1	10.3	376.51	15.3	0.925
11-Aug-00	1:00 PM	15.5	14.6	14.3	10.7	377.52	14.6	0.925
11-Aug-00	1:30 PM	15.1	14.3	14.3	10.7	378.51	14.5	0.925
11-Aug-00	2:00 PM	13.9	13.4	13.9	10.9	379.42	13.7	0.924
11-Aug-00	2:30 PM	20.8	13.9	13.9	10.9	380.39	13.3	0.924
11-Aug-00	3:00 PM	12.6	14.7	14.3	11.1	381.39	12.9	0.924
11-Aug-00	3:30 PM	11.7	11.8	14.3	11.1	382.17	16.3	0.924
11-Aug-00	4:00 PM	8.3	8.7	10.3	11.2	382.67	17.3	0.924
11-Aug-00	4:30 PM	13	13.2	10.3	11.2	383.56	23.6	0.924
11-Aug-00	5:00 PM	15	13.5	13.4	11.3	384.48	19.3	0.924
11-Aug-00	5:30 PM	15.9	14.9	13.4	11.3	385.52	18.4	0.925
11-Aug-00	6:00 PM	15.1	15.1	15	11.2	386.57	18.2	0.925

11-Aug-00	6:30 PM	13.2	13.2	15	11.2	387.46	16.9	0.926
11-Aug-00	7:00 PM	12.6	12.7	12.9	11	388.31	15.8	0.926
11-Aug-00	7:30 PM	11.7	12.3	12.9	11	389.12	15.1	0.926
11-Aug-00	8:00 PM	9.9	9.6	10.9	11	389.7	14.6	0.926
11-Aug-00	8:30 PM	6.9	9.4	10.9	11	390.25	12.5	0.926
11-Aug-00	9:00 PM	8	7.1	8.2	10.5	390.61	11.5	0.927
11-Aug-00	9:30 PM	10.9	10	8.2	10.5	391.22	10.6	0.927
11-Aug-00	10:00 PM	7.8	7.4	8.7	10.2	391.61	9.9	0.927
11-Aug-00	10:30 PM	7.7	6.9	8.7	10.2	391.95	9.7	0.928
11-Aug-00	11:00 PM	4.9	5.3	6.1	10	392.14	9.5	0.928
11-Aug-00	11:30 PM	3.9	4	6.1	10	392.23	9	0.928
12-Aug-00	12:00 AM	2.9	2.7	3.3	9.7	392.19	8.6	0.928
12-Aug-00	12:30 AM	4.3	4	3.3	9.7	392.28	8.3	0.928
12-Aug-00	1:00 AM	1.6	1.9	3	9.5	392.19	7.9	0.928
12-Aug-00	1:30 AM	3.7	3.6	3	9.5	392.24	7.7	0.928
12-Aug-00	2:00 AM	2.5	2.9	3.3	9.2	392.23	7.4	0.928
12-Aug-00	2:30 AM	2.2	2.8	3.3	9.2	392.21	6.7	0.928
12-Aug-00	3:00 AM	5.3	4.3	3.6	9.1	392.33	6.2	0.928
12-Aug-00	3:30 AM	4.5	4.5	3.6	9.1	392.46	5.9	0.928
12-Aug-00	4:00 AM	5	4.7	4.6	9	392.61	5.2	0.928
12-Aug-00	4:30 AM	5.6	5.1	4.6	9	392.8	5.1	0.929
12-Aug-00	5:00 AM	5.7	5.8	5.5	8.9	393.04	4.2	0.928
12-Aug-00	5:30 AM	7.3	6.5	5.5	8.9	393.35	4.5	0.928
12-Aug-00	6:00 AM	6.7	6.4	6.5	8.9	393.65	4	0.928
12-Aug-00	6:30 AM	5.8	5.5	6.5	8.9	393.87	3.7	0.928
12-Aug-00	7:00 AM	8.3	7.5	6.5	8.7	394.26	4.9	0.928
12-Aug-00	7:30 AM	7.9	9.8	6.5	8.7	394.85	7	0.929
12-Aug-00	8:00 AM	6	6.9	8.4	8.8	395.2	8.6	0.929
12-Aug-00	8:30 AM	0.7	4.7	8.4	8.8	395.35	10	0.929
12-Aug-00	9:00 AM	3.8	4	4.4	8.7	395.44	11.5	0.929
12-Aug-00	9:30 AM	1.9	3.9	4.4	8.7	395.51	14.4	0.929
12-Aug-00	10:00 AM	1.3	2	3	8.4	395.43	15.6	0.929
12-Aug-00	10:30 AM	2.8	4.3	3	8.4	395.55	16.8	0.929
12-Aug-00	11:00 AM	4.1	5.2	4.8	8.3	395.74	19.1	0.93
12-Aug-00	11:30 AM	1.9	3	4.8	8.3	395.74	19.7	0.93
12-Aug-00	12:00 PM	1.9	5.3	4.2	7.9	395.94	20.9	0.93
12-Aug-00	12:30 PM	2.9	4.3	4.2	7.9	396.06	21.6	0.929
12-Aug-00	1:00 PM	1.9	3.3	3.8	7.4	396.08	24.7	0.93
12-Aug-00	1:30 PM	2.3	2.8	3.8	7.4	396.07	24.2	0.93
12-Aug-00	2:00 PM	5.1	4.5	3.6	7	396.2	26.1	0.929
12-Aug-00	2:30 PM	6	3.2	3.6	7	396.22	24.9	0.929
12-Aug-00	3:00 PM	9.1	6.4	4.8	6.6	396.51	27.8	0.929
12-Aug-00	3:30 PM	3.2	4.5	4.8	6.6	396.65	26.9	0.929
12-Aug-00	4:00 PM	10.1	6.9	5.7	6.4	396.99	25.3	0.929
12-Aug-00	4:30 PM	7.9	6.7	5.7	6.4	397.32	28.4	0.928
12-Aug-00	5:00 PM	5.6	9.6	8.1	6.2	397.9	22.7	0.928
12-Aug-00	5:30 PM	4.7	4.7	8.1	6.2	398.03	22	0.927
12-Aug-00	6:00 PM	7	5	4.8	5.8	398.21	19.7	0.927
12-Aug-00	6:30 PM	3.9	5.8	4.8	5.8	398.45	19.5	0.927
12-Aug-00	7:00 PM	5.5	5.6	5.7	5.5	398.68	17.4	0.927
12-Aug-00	7:30 PM	6.2	7	5.7	5.5	399.03	17.6	0.926
12-Aug-00	8:00 PM	12.3	8.6	7.8	5.3	399.52	16.1	0.926
12-Aug-00	8:30 PM	9.2	12	7.8	5.3	400.3	14.9	0.926
12-Aug-00	9:00 PM	8.4	8.3	10.2	5.4	400.77	12.7	0.926
12-Aug-00	9:30 PM	7.1	7.8	10.2	5.4	401.18	11.6	0.926
12-Aug-00	10:00 PM	7.7	9.9	8.8	5.4	401.78	11.2	0.926
12-Aug-00	10:30 PM	9.6	7.7	8.8	5.4	402.2	10.9	0.926
12-Aug-00	11:00 PM	13.9	16	11.8	5.7	403.33	9.2	0.925
12-Aug-00	11:30 PM	8.4	8.1	11.8	5.7	403.78	9.4	0.926
13-Aug-00	12:00 AM	8.5	8.9	8.5	5.9	404.29	8.8	0.926
13-Aug-00	12:30 AM	5.7	6.8	8.5	5.9	404.62	8.6	0.925
13-Aug-00	1:00 AM	16.3	12.7	9.7	6.2	405.47	9.1	0.925

213

13-Aug-00	1:30 AM	6.5	8.7	9.7	6.2	405.97	9.2	0.925
13-Aug-00	2:00 AM	7.3	7.4	8	6.4	406.35	8.9	0.925
13-Aug-00	2:30 AM	6.8	7.1	8	6.4	406.7	9.4	0.924
13-Aug-00	3:00 AM	9.5	7.9	7.5	6.5	407.13	8.8	0.924
13-Aug-00	3:30 AM	7.3	7.9	7.5	6.5	407.56	9.3	0.924
13-Aug-00	4:00 AM	7.6	9.2	8.6	6.7	408.1	9	0.924
13-Aug-00	4:30 AM	6.8	7.7	8.6	6.7	408.51	8.5	0.924
13-Aug-00	5:00 AM	9.6	9.5	8.6	6.8	409.08	8.8	0.924
13-Aug-00	5:30 AM	10.2	9.4	8.6	6.8	409.64	9.4	0.924
13-Aug-00	6:00 AM	16.8	13.7	11.5	7	410.57	9.4	0.924
13-Aug-00	6:30 AM	9.5	10.8	11.5	7	411.25	9.4	0.924
13-Aug-00	7:00 AM	3.7	6.3	8.6	7.1	411.54	9.3	0.924
13-Aug-00	7:30 AM	4.7	4	8.6	7.1	411.63	8.5	0.924
13-Aug-00	8:00 AM	1.8	7.5	5.7	7	412.02	9.9	0.924
13-Aug-00	8:30 AM	2.7	5.1	5.7	7	412.21	12.1	0.924
13-Aug-00	9:00 AM	5.1	6.3	5.7	7.1	412.5	14.9	0.924
13-Aug-00	9:30 AM	2.8	3.6	5.7	7.1	412.55	13.9	0.924
13-Aug-00	10:00 AM	2.9	4.5	4.1	7.1	412.67	15.6	0.924
13-Aug-00	10:30 AM	3.4	4.3	4.1	7.1	412.79	17.8	0.924
13-Aug-00	11:00 AM	4.7	4.4	4.4	7.1	412.92	20.5	0.925
13-Aug-00	11:30 AM	1.1	2.9	4.4	7.1	412.9	19.6	0.925
13-Aug-00	12:00 PM	3	4.1	3.5	7.1	413	17.5	0.925
13-Aug-00	12:30 PM	6.5	9.1	3.5	7.1	413.54	15.9	0.924
13-Aug-00	1:00 PM	6	4.1	6.6	7.2	413.64	17.7	0.924
13-Aug-00	1:30 PM	4.8	3.6	6.6	7.2	413.68	16.5	0.924
13-Aug-00	2:00 PM	5.4	10.7	7.1	7.3	414.35	13.1	0.923
13-Aug-00	2:30 PM	2.5	3.1	7.1	7.3	414.37	19.1	0.924
13-Aug-00	3:00 PM	0	0.6	1.9	7.2	414.16	17	0.924
13-Aug-00	3:30 PM	2.9	2.6	1.9	7.2	414.13	22	0.924
13-Aug-00	4:00 PM	0.2	1.7	2.1	7.1	414.01	23.5	0.924
13-Aug-00	4:30 PM	6.4	6.7	2.1	7.1	414.33	19.3	0.924
13-Aug-00	5:00 PM	1.9	6	6.3	7	414.59	16.8	0.924
13-Aug-00	5:30 PM	8.5	8.6	6.3	7	415.09	14.9	0.924
13-Aug-00	6:00 PM	6.6	7.4	8	7.1	415.47	15.6	0.924
13-Aug-00	6:30 PM	9.4	5.7	8	7.1	415.7	14.1	0.924
13-Aug-00	7:00 PM	9.8	8.1	6.9	7.2	416.14	13.1	0.924
13-Aug-00	7:30 PM	8.8	7.9	6.9	7.2	416.57	11.9	0.924
13-Aug-00	8:00 PM	5.7	6.4	7.1	7.1	416.86	11.3	0.924
13-Aug-00	8:30 PM	5.8	6.3	7.1	7.1	417.15	10.6	0.924
13-Aug-00	9:00 PM	7.5	6.5	6.4	7	417.46	9.9	0.925
13-Aug-00	9:30 PM	6.4	6.9	6.4	7	417.81	9.2	0.925
13-Aug-00	10:00 PM	3.8	4.4	5.7	6.8	417.93	9.3	0.925
13-Aug-00	10:30 PM	4.3	4.6	5.7	6.8	418.07	9.4	0.925
13-Aug-00	11:00 PM	4.5	4.3	4.5	6.5	418.18	8.2	0.925
13-Aug-00	11:30 PM	5.5	4.7	4.5	6.5	418.33	7	0.925
14-Aug-00	12:00 AM	4	5	4.8	6.4	418.5	6.4	0.925
14-Aug-00	12:30 AM	5.2	5.2	4.8	6.4	418.69	5.9	0.925
14-Aug-00	1:00 AM	4.8	5.3	5.2	6.2	418.89	5.8	0.926
14-Aug-00	1:30 AM	4.5	4.3	5.2	6.2	419	5.1	0.925
14-Aug-00	2:00 AM	5.4	5.6	4.9	6.1	419.23	5.2	0.926
14-Aug-00	2:30 AM	5.1	5.3	4.9	6.1	419.43	4.9	0.926
14-Aug-00	3:00 AM	3.8	4	4.7	6	419.52	4.4	0.926
14-Aug-00	3:30 AM	4	3.7	4.7	6	419.58	3.6	0.926
14-Aug-00	4:00 AM	5.1	4.4	4	5.8	419.7	3.6	0.926
14-Aug-00	4:30 AM	5	5.1	4	5.8	419.88	3.1	0.926
14-Aug-00	5:00 AM	4	4.4	4.7	5.6	420	2.9	0.926
14-Aug-00	5:30 AM	5.1	5.8	4.7	5.6	420.24	2.9	0.926
14-Aug-00	6:00 AM	4.9	4.9	5.4	5.3	420.41	2.8	0.926
14-Aug-00	6:30 AM	5.6	5.5	5.4	5.3	420.63	2.6	0.926
14-Aug-00	7:00 AM	7.3	6.3	5.9	5.2	420.92	3	0.926
14-Aug-00	7:30 AM	4.9	6.9	5.9	5.2	421.26	5	0.926
14-Aug-00	8:00 AM	1	6.1	6.5	5.3	421.53	6.9	0.926

14-Aug-00	8:30 AM	5.7	3.7	6.5	5.3	421.59	6.2	0.927
14-Aug-00	9:00 AM	11.6	9	6.4	5.3	422.12	10	0.927
14-Aug-00	9:30 AM	2	0	6.4	5.3	421.82	14.3	0.927
14-Aug-00	10:00 AM	0	1.4	0.6	5.1	421.69	15.7	0.927
14-Aug-00	10:30 AM	0.2	1.4	0.6	5.1	421.55	16.2	0.928
14-Aug-00	11:00 AM	3	2.4	1.9	5	421.5	17.3	0.928
14-Aug-00	11:30 AM	6.1	5.8	1.9	5	421.74	20.5	0.928
14-Aug-00	12:00 PM	2.4	3.1	4.5	5.1	421.75	20.9	0.928
14-Aug-00	12:30 PM	2.6	0	4.5	5.1	421.49	22	0.928
14-Aug-00	1:00 PM	5.7	3.9	1.9	4.9	421.57	23.5	0.928
14-Aug-00	1:30 PM	2.4	3.7	1.9	4.9	421.63	24	0.928
14-Aug-00	2:00 PM	3.6	5.4	4.5	4.8	421.83	21.8	0.929
14-Aug-00	2:30 PM	5.6	7	4.5	4.8	422.19	25.1	0.929
14-Aug-00	3:00 PM	3.4	7.2	7.1	5	422.56	25.3	0.929
14-Aug-00	3:30 PM	5	7	7.1	5	422.9	23.3	0.929
14-Aug-00	4:00 PM	3.2	6.3	6.7	5.2	423.19	26.8	0.929
14-Aug-00	4:30 PM	4.2	6	6.7	5.2	423.46	24.1	0.928
14-Aug-00	5:00 PM	6.5	8.3	7.2	5.2	423.92	23.3	0.928
14-Aug-00	5:30 PM	8.7	6	7.2	5.2	424.18	22.2	0.928
14-Aug-00	6:00 PM	7.2	7.5	6.7	5.2	424.58	19.2	0.928
14-Aug-00	6:30 PM	6.2	6.4	6.7	5.2	424.87	18.9	0.928
14-Aug-00	7:00 PM	6.8	7.1	6.7	5.2	425.22	17.3	0.928
14-Aug-00	7:30 PM	10.5	8.2	6.7	5.2	425.68	16.7	0.928
14-Aug-00	8:00 PM	10.6	9.4	8.8	5.2	426.24	15.1	0.928
14-Aug-00	8:30 PM	10.4	9.8	8.8	5.2	426.83	13.3	0.928
14-Aug-00	9:00 PM	13.2	11.6	10.7	5.4	427.59	12.2	0.928
14-Aug-00	9:30 PM	11	12.9	10.7	5.4	428.45	11.2	0.928
14-Aug-00	10:00 PM	8.5	9.6	11.2	5.6	429.03	10.6	0.928
14-Aug-00	10:30 PM	8.5	8.9	11.2	5.6	429.55	10.5	0.928
14-Aug-00	11:00 PM	8.1	8.8	8.9	5.8	430.05	9.9	0.928
14-Aug-00	11:30 PM	7.6	8.3	8.9	5.8	430.51	9.6	0.928
15-Ang-00	12:00 AM	7.1	7.6	7.9	6	430.91	9	0.929
15-Aug-00	12:30 AM	7.5	8	7.9	6	431.35	7.8	0.929
15-Aug-00	1:00 AM	6.8	7.1	7.5	6.1	431.71	7.2	0.929
15-Aug-00	1:30 AM	6.2	6.5	7.5	6.1	432.01	8	0.929
15-Aug-00	2:00 AM	5.9	6.4	6.4	6.1	432.31	7.5	0.929
15-Aug-00	2:30 AM	5.7	6.3	6.4	6.1	432.59	7.1	0.929
15-Aug-00	3:00 AM	5.4	5.6	5.9	6.2	432.82	6.7	0.929
15-Aug-00	3:30 AM	4.6	5.5	5.9	6.2	433.04	6.3	0.929
15-Aug-00	4:00 AM	4.1	4.7	5.1	6.2	433.19	7.6	0.929
15-Aug-00	4:30 AM	4.5	4.5	5.1	6.2	433.32	8.7	0.929
15-Aug-00	5:00 AM	5	5	4.8	6.2	433.49	8.7	0.929
15-Aug-00	5:30 AM	6.2	6	4.8	6.2	433.76	8.6	0.929
15-Aug-00	6:00 AM	6.1	6.1	6.1	6.2	434.03	7.7	0.929
15-Aug-00	6:30 AM	6.6	6.7	6.1	6.2	434.35	7.5	0.929
15-Aug-00	7:00 AM	6.9	7.1	6.9	6.3	434.71	8.3	0.93
15-Aug-00	7:30 AM	8.5	9.6	6.9	6.3	435.29	10	0.93
15-Aug-00	8:00 AM	9.9	9.2	9.4	6.4	435.84	12.3	0.93
15-Aug-00	8:30 AM	7.8	8.7	9.4	6.4	436.33	14.7	0.93
15-Aug-00	9:00 AM	5	6.9	7.8	6.5	436.67	16.8	0.93
15-Aug-00	9:30 AM	3.2	3.6	7.8	6.5	436.72	17.5	0.93
15-Aug-00	10:00 AM	3.6	6.1	4.9	6.6	436.99	18.9	0.93
15-Aug-00	10:30 AM	8	7	4.9	6.6	437.34	19.8	0.93
15-Aug-00	11:00 AM	8.4	8.2	7.6	6.9	437.8	20.5	0.931
15-Aug-00	11:30 AM	13.8	12.8	7.6	6.9	438.66	22.7	0.931
15-Aug-00	12:00 PM	11.4	10.6	11.7	7.2	439.32	22.4	0.93
15-Aug-00	12:30 PM	9.4	9.7	11.7	7.2	439.9	23	0.93
15-Aug-00	1:00 PM	16	15.3	12.5	7.6	440.98	23.9	0.93
15-Aug-00	1:30 PM	17.1	15.5	12.5	7.6	442.08	25.6	0.931
15-Aug-00	2:00 PM	14.5	13.6	14.6	8	443	25.5	0.931
15-Aug-00	2:30 PM	13.2	12.4	14.6	8	443.83	26.7	0.931
15-Aug-00	3:00 PM	9.9	11.2	11.8	8.2	444.54	26.5	0.93

215

15-Aug-00	3:30 PM	12.6	13.8	11.8	8.2	445.49	30	0.93
15-Aug-00	4:00 PM	11.2	12.2	13	8.5	446.29	32	0.93
15-Aug-00	4:30 PM	12.1	11.5	13	8.5	447.03	32.3	0.93
15-Aug-00	5:00 PM	10.3	14.2	12.8	8.7	448	26.5	0.93
15-Aug-00	5:30 PM	19.8	14.8	12.8	8.7	449.04	23.1	0.93
15-Aug-00	6:00 PM	11.8	16.5	15.6	9.1	450.21	21.3	0.929
15-Aug-00	6:30 PM	14.5	13.6	15.6	9.1	451.14	20	0.929
15-Aug-00	7:00 PM	15.3	15.6	14.6	9.4	452.25	20.3	0.929
15-Aug-00	7:30 PM	13.3	16.7	14.6	9.4	453.44	18.8	0.929
15-Aug-00	8:00 PM	22.2	19.3	18	9.8	454.86	17.3	0.929
15-Aug-00	8:30 PM	19.7	21.2	18	9.8	456.46	16.1	0.929
15-Aug-00	9:00 PM	15.8	18	19.6	10.2	457.77	14.8	0.929
15-Aug-00	9:30 PM	16.3	16.6	19.6	10.2	458.96	13.7	0.929
15-Aug-00	10:00 PM	12.7	15.4	16	10.4	460.04	13.1	0.929
15-Aug-00	10:30 PM	11.9	12.6	16	10.4	460.87	12.2	0.929
15-Aug-00	11:00 PM	6.5	8.5	10.5	10.5	461.35	11.8	0.929
15-Aug-00	11:30 PM	7.5	8.6	10.5	10.5	461.84	11.6	0.929
16-Aug-00	12:00 AM	10.3	9.6	9.1	10.5	462.42	10.7	0.929
16-Aug-00	12:30 AM	12.2	10.7	9.1	10.5	463.09	10.1	0.929
16-Aug-00	1:00 AM	11.1	11.5	11.1	10.7	463.84	11.3	0.93
16-Aug-00	1:30 AM	12.8	12.9	11.1	10.7	464.7	12.3	0.93
16-Aug-00	2:00 AM	10.7	10	11.5	10.9	465.31	12	0.93
16-Aug-00	2:30 AM	7.5	8.6	11.5	10.9	465.8	10.6	0.93
16-Aug-00	3:00 AM	8.5	9.3	8.9	11	466.35	9.7	0.931
16-Aug-00	3:30 AM	8.5	8.8	8.9	11	466.85	8.8	0.931
16-Aug-00	4:00 AM	8.1	9.2	9	11.2	467.4	8	0.931
16-Aug-00	4:30 AM	10	9.3	9	11.2	467.95	8.3	0.932
16-Aug-00	5:00 AM	7.7	7.7	8.5	11.3	468.36	7.9	0.932
16-Aug-00	5:30 AM	7.9	8.3	8.5	11.3	468.83	8.1	0.932
16-Aug-00	6:00 AM	8.3	8.7	8.5	11.4	469.32	7.6	0.932
16-Aug-00	6:30 AM	7.5	8.5	8.5	11.4	469.8	7.5	0.932
16-Aug-00	7:00 AM	10.8	9.1	8.8	11.5	470.34	8.1	0.932
16-Aug-00	7:30 AM	6.1	6.3	8.8	11.5	470.63	10.5	0.932
16-Aug-00	8:00 AM	8.1	7.6	6.9	11.4	471.03	12.7	0.933
16-Aug-00	8:30 AM	6.3	7.2	6.9	11.4	471.39	14.7	0.933
16-Aug-00	9:00 AM	6.1	6	6.6	11.3	471.65	13.1	0.933
16-Aug-00	9:30 AM	8.7	8.7	6.6	11.3	472.16	14.7	0.934
16-Aug-00	10:00 AM	7.6	9.3	9	11.5	472.7	14.8	0.934
16-Aug-00	10:30 AM	20.7	11.4	9	11.5	473.45	14.7	0.935
16-Aug-00	11:00 AM	11.4	18	14.7	11.8	474.75	15.6	0.935
16-Aug-00	11:30 AM	9.4	11.7	14.7	11.8	475.51	15.9	0.935
16-Aug-00	12:00 PM	2	5.5	8.6	11.7	475.72	20.1	0.935
16-Aug-00	12:30 PM	2.6	5.8	8.6	11.7	475.97	22.4	0.935
16-Aug-00	1:00 PM	2.3	4.3	5	11.4	476.08	23.4	0.936
16-Aug-00	1:30 PM	8.5	7.8	5	11.4	476.5	18.8	0.936
16-Aug-00	2:00 PM	13.2	6.7	7.2	11.1	476.83	17.8	0.936
16-Aug-00	2:30 PM	9.8	12.2	7.2	11.1	477.63	23	0.936
16-Aug-00	3:00 PM	12.2	11.3	11.7	11.1	478.35	15.7	0.936
16-Aug-00	3:30 PM	3.8	5.4	11.7	11.1	478.56	15.4	0.936
16-Aug-00	4:00 PM	3.9	9.2	7.3	10.8	479.1	17.2	0.936
16-Aug-00	4:30 PM	4.7	2.3	7.3	10.8	479.04	19.6	0.936
16-Aug-00	5:00 PM	6.3	4.9	3.6	10.4	479.2	18.4	0.936
16-Aug-00	5:30 PM	2.2	3.7	3.6	10.4	479.26	17.4	0.936
16-Aug-00	6:00 PM	6.1	6.3	5	10	479.56	16.1	0.936
16-Aug-00	6:30 PM	7.4	8	5	10	479.99	15.4	0.935
16-Aug-00	7:00 PM	6.9	6.8	7.4	9.7	480.32	13.9	0.936
16-Aug-00	7:30 PM	9.1	9.2	7.4	9.7	480.86	13.2	0.936
16-Aug-00	8:00 PM	11.5	10.7	10	9.4	481.54	12.8	0.936
16-Aug-00	8:30 PM	12	12.3	10	9.4	482.35	11.5	0.936
16-Aug-00	9:00 PM	10.4	10.8	11.6	9	483.03	9.9	0.936
16-Aug-00	9:30 PM	12	10.9	11.6	9	483.73	8.8	0.936
16-Aug-00	10:00 PM	9.1	10.2	10.5	8.8	484.35	8.3	0.936

216

16-Aug-00	10:30 PM	8.7	8.3	10.5	8.8	484.81	7.5	0.936
16-Aug-00	11:00 PM	8.6	8	8.2	8.7	485.25	7.2	0.936
16-Aug-00	11:30 PM	8.4	9.5	8.2	8.7	485.82	6.7	0.936
17-Aug-00	12:00 AM	10.7	10.4	10	8.7	486.47	6.6	0.935
17-Aug-00	12:30 AM	11.5	10.8	10	8.7	487.16	6.8	0.935
17-Aug-00	1:00 AM	8	10.1	10.5	8.7	487.77	7.8	0.935
17-Aug-00	1:30 AM	7.3	6.9	10.5	8.7	488.12	7.9	0.935
17-Aug-00	2:00 AM	3.8	6.2	6.6	8.5	488.4	7.5	0.935
17-Aug-00	2:30 AM	5.5	6.1	6.6	8.5	488.67	7.1	0.935
17-Aug-00	3:00 AM	7.9	8	7	8.4	489.1	7.5	0.935
17-Aug-00	3:30 AM	8.9	8.3	7	8.4	489.56	7.7	0.934
17-Aug-00	4:00 AM	7.9	7.5	7.9	8.4	489.96	8.2	0.934
17-Aug-00	4:30 AM	7.9	7.6	7.9	8.4	490.36	8.4	0.934
17-Aug-00	5:00 AM	7.4	7.1	7.4	8.3	490.72	8.8	0.934
17-Aug-00	5:30 AM	6.6	7.6	7.4	8.3	491.12	8.9	0.934
17-Aug-00	6:00 AM	7	7.3	7.4	8.3	491.49	9.1	0.934
17-Aug-00	6:30 AM	7.8	7.7	7.4	8.3	491.9	9.4	0.933
17-Aug-00	7:00 AM	7.4	8.4	8	8.3	492.37	9.8	0.933
17-Aug-00	7:30 AM	5.9	6.9	8	8.3	492.7	10.1	0.933
17-Aug-00	8:00 AM	9	8.4	7.6	8.3	493.18	10.2	0.933
17-Aug-00	8:30 AM	7.6	8.1	7.6	8.3	493.62	10.7	0.933
17-Aug-00	9:00 AM	7.4	8	8	8.3	494.06	11.5	0.933
17-Aug-00	9:30 AM	9.6	9.5	8	8.3	494.63	12.2	0.933
17-Aug-00	10:00 AM	9.8	9.6	9.5	8.4	495.21	12.6	0.932
17-Aug-00	10:30 AM	11.3	10.8	9.5	8.4	495.89	13.2	0.932
17-Aug-00	11:00 AM	12.2	11.1	11	8.2	496.6	14.7	0.932
17-Aug-00	11:30 AM	11.3	11.4	11	8.2	497.33	16.8	0.931
17-Aug-00	12:00 PM	19.9	14.7	13	8.4	498.36	18.6	0.931
17-Aug-00	12:30 PM	13.7	14.4	13	8.4	499.35	18.6	0.931
17-Aug-00	1:00 PM	15.8	17.9	16.1	8.9	500.65	19.5	0.93
17-Aug-00	1:30 PM	16	16.7	16.1	8.9	501.85	18.9	0.93
17-Aug-00	2:00 PM	15.7	16.5	16.6	9.2	503.03	22	0.93
17-Aug-00	2:30 PM	18.3	16.8	16.6	9.2	504.24	20.4	0.93
17-Aug-00	3:00 PM	18.9	21.1	19	9.5	505.83	23.5	0.929
17-Aug-00	3:30 PM	19.3	17.7	19	9.5	507.11	25.1	0.929
17-Aug-00	4:00 PM	16.9	17.1	17.4	10	508.34	25.4	0.928
17-Aug-00	4:30 PM	17.5	17.8	17.4	10	509.63	26.3	0.928
17-Aug-00	5:00 PM	19.3	21.4	19.6	10.6	511.23	23.6	0.927
17-Aug-00	5:30 PM	20.9	21.7	19.6	10.6	512.87	23.4	0.926
17-Aug-00	6:00 PM	20.2	20.7	21.2	11.3	514.42	22.4	0.926
17-Aug-00	6:30 PM	20.1	19.7	21.2	11.3	515.89	21.9	0.926
17-Aug-00	7:00 PM	17.3	19.2	19.5	11.8	517.29	21.2	0.925
17-Aug-00	7:30 PM	17.3	18.4	19.5	11.8	518.64	20.5	0.925
17-Aug-00	8:00 PM	17.7	19.5	19	12.2	520.08	18.8	0.924
17-Aug-00	8:30 PM	26.8	22.2	19	12.2	521.77	17.6	0.924
17-Aug-00	9:00 PM	28.8	32.5	27.3	12.8	524.34	15.8	0.924
17-Aug-00	9:30 PM	19.1	20.4	27.3	12.8	525.86	15	0.924
17-Aug-00	10:00 PM	17	18.2	19.3	13.2	527.19	14.7	0.923
17-Aug-00	10:30 PM	16	16.4	19.3	13.2	528.36	14.5	0.923
17-Aug-00	11:00 PM	14.1	14.9	15.7	13.5	529.4	14.5	0.923
17-Aug-00	11:30 PM	12	13.7	15.7	13.5	530.33	14.1	0.923
18-Aug-00	12:00 AM	13.2	13.2	13.4	13.7	531.22	13.6	0.923
18-Aug-00	12:30 AM	10.5	12.6	13.4	13.7	532.06	12.7	0.922
18-Aug-00	1:00 AM	10.9	12	12.3	13.7	532.84	12.9	0.922
18-Aug-00	1:30 AM	10.7	11.6	12.3	13.7	533.59	12.1	0.922
18-Aug-00	2:00 AM	9	11.4	11.5	14	534.33	9.4	0.922
18-Aug-00	2:30 AM	10.4	9.8	11.5	14	534.93	9.9	0.922
18-Aug-00	3:00 AM	9.6	10.2	10	14.1	535.55	9.3	0.921
18-Aug-00	3:30 AM	9.8	10.3	10	14.1	536.19	9.6	0.921
18-Aug-00	4:00 AM	10.1	10.4	10.3	14.2	536.83	9.6	0.921
18-Aug-00	4:30 AM	8.9	9.7	10.3	14.2	537.41	8.7	0.921
18-Aug-00	5:00 AM	9.7	9.7	9.7	14.3	538	7.7	0.921

18-Aug-00	5:30 AM	9.9	9.5	9.7	14.3	538.56	7.1	0.921
18-Aug-00	6:00 AM	9.3	9.3	9.4	14.4	539.12	6.5	0.921
18-Aug-00	6:30 AM	15.1	12.2	9.4	14.4	539.92	5.9	0.921
18-Aug-00	7:00 AM	17.3	16.8	14.5	14.6	541.13	7.1	0.921
18-Aug-00	7:30 AM	10.8	11.4	14.5	14.6	541.86	9.5	0.921
18-Aug-00	8:00 AM	16.5	19.6	15.5	15	543.31	13	0.921
18-Aug-00	8:30 AM	18.9	16.8	15.5	15	544.52	15.3	0.921
18-Aug-00	9:00 AM	18.2	17.5	17.2	15.3	545.79	17	0.921
18-Aug-00	9:30 AM	14.6	15.3	17.2	15.3	546.86	18.8	0.921
18-Aug-00	10:00 AM	17.4	18.9	17.1	15.6	548.24	20	0.921
18-Aug-00	10:30 AM	26.1	22.9	17.1	15.6	550	20.8	0.921
18-Aug-00	11:00 AM	22.2	22.8	22.8	16.1	551.71	22.4	0.921
18-Aug-00	11:30 AM	23.3	25.9	22.8	16.1	553.72	25.2	0.921
18-Aug-00	12:00 PM	27.4	25.9	25.9	16.7	555.72	24.1	0.921
18-Aug-00	12:30 PM	16.8	26.3	25.9	16.7	557.75	26.4	0.921
18-Aug-00	1:00 PM	23.8	23.5	24.9	17	559.55	25.6	0.921
18-Aug-00	1:30 PM	22	24.7	24.9	17	561.43	26.8	0.921
18-Aug-00	2:00 PM	26.2	24.1	24.4	17.4	563.28	28.2	0.921
18-Aug-00	2:30 PM	28.2	27.2	24.4	17.4	565.39	29.8	0.92
18-Aug-00	3:00 PM	24.6	25	26.1	17.7	567.31	28.2	0.92
18-Aug-00	3:30 PM	25.4	25.3	26.1	17.7	569.26	28.8	0.92
18-Aug-00	4:00 PM	24.4	26.1	25.7	18	571.27	28.4	0.919
18-Aug-00	4:30 PM	27	26.8	25.7	18	573.36	28.5	0.919
18-Aug-00	5:00 PM	27	28.8	27.8	18.4	575.61	25.2	0.918
18-Aug-00	5:30 PM	27.6	27.1	27.8	18.4	577.73	24.7	0.918
18-Aug-00	6:00 PM	31.2	32.1	29.6	18.7	580.27	23.8	0.917
18-Aug-00	6:30 PM	31.3	31.6	29.6	18.7	582.77	22.9	0.917
18-Aug-00	7:00 PM	34.3	31.8	31.7	19.2	585.29	21.7	0.916
18-Aug-00	7:30 PM	36.1	38.4	31.7	19.2	588.38	19.8	0.916
18-Aug-00	8:00 PM	44.4	38.8	38.6	20	591.52	17.8	0.916
18-Aug-00	8:30 PM	32.4	40.1	38.6	20	594.75	16.8	0.915
18-Aug-00	9:00 PM	44.5	43.6	41.9	20.6	598.31	15.5	0.915
18-Aug-00	9:30 PM	37.5	44	41.9	20.6	601.89	15.6	0.916
18-Aug-00	10:00 PM	31.9	32.6	38.3	21.4	604.47	16.2	0.915
18-Aug-00	10:30 PM	33.3	33.6	38.3	21.4	607.13	16.5	0.915
18-Aug-00	11:00 PM	27.6	27.9	30.7	22.1	609.31	15.4	0.915
18-Aug-00	11:30 PM	24	26.4	30.7	22.1	611.35	14.1	0.915
19-Aug-00	12:00 AM	17	20.2	23.3	22.5	612.85	13	0.915
19-Aug-00	12:30 AM	18.4	17.3	23.3	22.5	614.1	12.2	0.915
19-Aug-00	1:00 AM	15.8	15.5	16.4	22.6	615.2	11.4	0.915
19-Aug-00	1:30 AM	15.6	15.6	16.4	22.6	616.29	10.4	0.915
19-Aug-00	2:00 AM	15.2	17.3	16.4	22.8	617.54	10.7	0.915
19-Aug-00	2:30 AM	10.7	11	16.4	22.8	618.24	10.1	0.915
19-Aug-00	3:00 AM	14	13.2	12.1	22.9	619.13	10.2	0.916
19-Aug-00	3:30 AM	11.7	12.3	12.1	22.9	619.95	10.8	0.916
19-Aug-00	4:00 AM	9.5	11.2	11.8	23	620.66	11.3	0.916
19-Aug-00	4:30 AM	11.7	11.3	11.8	23	621.39	10.8	0.917
19-Aug-00	5:00 AM	12.3	11.4	11.4	23.1	622.13	10.3	0.917
19-Aug-00	5:30 AM	11.6	11.5	11.4	23.1	622.88	10.5	0.917
19-Aug-00	6:00 AM	3.4	8.1	9.8	23.1	623.31	10.8	0.917
19-Aug-00	6:30 AM	10.4	8.2	9.8	23.1	623.77	10.6	0.918
19-Aug-00	7:00 AM	12.9	10.7	9.5	22.9	624.45	10.9	0.918
19-Aug-00	7:30 AM	11.9	12.6	9.5	22.9	625.29	11.1	0.918
19-Aug-00	8:00 AM	12	12.4	12.5	22.7	626.12	11	0.919
19-Aug-00	8:30 AM	10.3	12	12.5	22.7	626.9	14.2	0.919
19-Aug-00	9:00 AM	5.9	7.5	9.8	22.4	627.29	15.7	0.919
19-Aug-00	9:30 AM	8.2	7.7	9.8	22.4	627.7	18.6	0.92
19-Aug-00	10:00 AM	8.5	9	8.3	22.1	628.22	20.5	0.92
19-Aug-00	10:30 AM	5.5	6.5	8.3	22.1	628.53	19.7	0.92
19-Aug-00	11:00 AM	7.4	10.3	8.4	21.5	629.17	22.7	0.921
19-Aug-00	11:30 AM	15.8	13.2	8.4	21.5	630.06	24.3	0.921
19-Aug-00	12:00 PM	9.2	12	12.6	20.9	630.83	25.6	0.921

19-Aug-00	12:30 PM	9.1	11	12.6	20.9	631.53	26	0.921
19-Aug-00	1:00 PM	6.1	6.7	8.9	20.2	631.86	26.9	0.922
19-Aug-00	1:30 PM	35.6	12.1	8.9	20.2	632.67	28.7	0.922
19-Aug-00	2:00 PM	41.3	29	20.5	20.1	634.96	29.6	0.922
19-Aug-00	2:30 PM	12.9	12	20.5	20.1	635.72	29.3	0.922
19-Aug-00	3:00 PM	12.3	14.2	13.1	19.5	636.69	27.3	0.922
19-Aug-00	3:30 PM	8.3	7.6	13.1	19.5	637.1	27.9	0.922
19-Aug-00	4:00 PM	8.8	9.9	8.7	18.8	637.72	26.9	0.922
19-Aug-00	4:30 PM	9.2	11.7	8.7	18.8	638.46	27	0.922
19-Aug-00	5:00 PM	42.4	18.3	15	18.3	639.85	17.7	0.922
19-Aug-00	5:30 PM	25.9	31.6	15	18.3	642.31	11.3	0.923
19-Aug-00	6:00 PM	8.3	12.7	22.1	18	643.15	10.6	0.922
19-Aug-00	6:30 PM	7.9	6.8	22.1	18	643.48	11.4	0.921
19-Aug-00	7:00 PM	13.7	8.4	7.6	17	643.95	11.7	0.921
19-Aug-00	7:30 PM	6.8	8.8	7.6	17	644.46	11.2	0.921
19-Aug-00	8:00 PM	0.9	4.2	6.5	15.7	644.55	12.2	0.921
19-Aug-00	8:30 PM	10	6.4	6.5	15.7	644.86	11.4	0.921
19-Aug-00	9:00 PM	11.8	15.2	10.8	14.4	645.92	10.8	0.921
19-Aug-00	9:30 PM	7.4	9.7	10.8	14.4	646.5	9.4	0.921
19-Aug-00	10:00 PM	9	7.5	8.6	13.1	646.9	8.8	0.922
19-Aug-00	10:30 PM	5	7.4	8.6	13.1	647.28	9.4	0.922
19-Aug-00	11:00 PM	4.8	5.6	6.5	12.1	647.5	8.7	0.922
19-Aug-00	11:30 PM	7.1	6.8	6.5	12.1	647.83	8.2	0.922
20-Aug-00	12:00 AM	4.7	6	6.4	11.4	648.09	8.8	0.922
20-Aug-00	12:30 AM	4.7	6.1	6.4	11.4	648.36	8	0.922
20-Aug-00	1:00 AM	5.8	5.7	5.9	11	648.6	7	0.922
20-Aug-00	1:30 AM	7.7	6.8	5.9	11	648.93	7	0.923
20-Aug-00	2:00 AM	5.6	6	6.4	10.5	649.19	7.1	0.923
20-Aug-00	2:30 AM	4.3	6.7	6.4	10.5	649.51	7.2	0.923
20-Aug-00	3:00 AM	7	6	6.3	10.3	649.78	6.6	0.923
20-Aug-00	3:30 AM	5	5.5	6.3	10.3	650	6.2	0.924
20-Aug-00	4:00 AM	5.3	5.9	5.7	10.1	650.26	5.5	0.924
20-Aug-00	4:30 AM	6.1	6.3	5.7	10.1	650.54	6.1	0.924
20-Aug-00	5:00 AM	5.7	5.6	6	9.8	650.77	5.5	0.924
20-Aug-00	5:30 AM	5.3	5.4	6	9.8	650.98	4.6	0.924
20-Aug-00	6:00 AM	5.1	5.6	5.5	9.6	651.21	4.8	0.924
20-Aug-00	6:30 AM	4.9	4.5	5.5	9.6	651.33	4.3	0.924
20-Aug-00	7:00 AM	5.3	5.5	5	9.5	651.55	4.4	0.924
20-Aug-00	7:30 AM	4.3	5.1	5	9.5	651.73	6.7	0.924
20-Aug-00	8:00 AM	5.1	5.2	5.2	9.2	651.93	9.7	0.924
20-Aug-00	8:30 AM	2.8	3.8	5.2	9.2	651.99	11.9	0.924
20-Aug-00	9:00 AM	3	3.4	3.6	8.9	652.03	14.1	0.925
20-Aug-00	9:30 AM	1.9	3.6	3.6	8.9	652.09	15.4	0.925
20-Aug-00	10:00 AM	5.2	5	4.3	8.7	652.26	18.8	0.926
20-Aug-00	10:30 AM	2.8	4.4	4.3	8.7	652.37	20.9	0.926
20-Aug-00	11:00 AM	4.8	4.1	4.2	8.6	652.48	20.4	0.926
20-Aug-00	11:30 AM	6	6.7	4.2	8.6	652.8	22.4	0.927
20-Aug-00	12:00 PM	5.6	6.8	6.8	8.3	653.13	22.8	0.927
20-Aug-00	12:30 PM	1.7	2.5	6.8	8.3	653.1	23.3	0.927
20-Aug-00	1:00 PM	0	4.7	3.6	8.1	653.25	25.9	0.927
20-Aug-00	1:30 PM	9.7	3.8	3.6	8.1	653.33	27.2	0.927
20-Aug-00	2:00 PM	2.6	3.3	3.6	7.4	653.33	28.3	0.927
20-Aug-00	2:30 PM	8.7	4.1	3.6	7.4	653.45	26.6	0.927
20-Aug-00	3:00 PM	1.6	5.8	5	7.1	653.69	27.7	0.927
20-Aug-00	3:30 PM	3.1	5.1	5	7.1	653.87	28.8	0.927
20-Aug-00	4:00 PM	12.3	7.3	6.2	6.9	654.27	26.2	0.927
20-Aug-00	4:30 PM	5.6	5.2	6.2	6.9	654.46	25.6	0.927
20-Aug-00	5:00 PM	7	8	6.6	6.6	654.88	23.5	0.926
20-Aug-00	5:30 PM	11.1	6.4	6.6	6.6	655.19	18.4	0.926
20-Aug-00	6:00 PM	5.7	8.7	7.6	6	655.68	17.5	0.926
20-Aug-00	6:30 PM	8.4	5.1	7.6	6	655.86	16.8	0.925
20-Aug-00	7:00 PM	13.8	11.9	8.5	6	656.64	15.9	0.926

20-Aug-00	7:30 PM	5.6	6.9	8.5	6	656.98	16.4	0.926
20-Aug-00	8:00 PM	6.5	7.3	7.1	6.1	657.35	13.3	0.925
20-Aug-00	8:30 PM	8.9	9.1	7.1	6.1	657.89	11.1	0.925
20-Aug-00	9:00 PM	11.8	10.8	10	6	658.58	9.3	0. 41
20-Aug-00	9:30 PM	9.3	11.9	10	6	659.35	8.8	0.926
20-Aug-00	10:00 PM	11.1	12.4	12.1	6.2	660.17	7.9	0.925
20-Aug-00	10:30 PM	11.3	13.1	12.1	6.2	661.05	7.9	0.925
20-Aug-00	11:00 PM	11.8	12.5	12.8	6.4	661.88	8.6	0.925
20-Aug-00	11:30 PM	10.1	11	12.8	6.4	662.58	8.1	0.925
21-Aug-00	12:00 AM	7.2	8.8	9.9	6.6	663.09	8.2	0.925
21-Aug-00	12:30 AM	8.1	8.4	9.9	6.6	663.57	8.6	0.925
21-Aug-00	1:00 AM	8.4	8.3	8.4	6.7	664.03	8.4	0.926
21-Aug-00	1:30 AM	6.4	6.3	8.4	6.7	664.32	7.7	0.926
21-Aug-00	2:00 AM	5.6	7.4	6.8	6.7	664.7	7.9	0.926
21-Aug-00	2:30 AM	6.3	6.4	6.8	6.7	664.99	8	0.926
21-Aug-00	3:00 AM	5.9	6.4	6.4	6.7	665.29	7.5	0.925
21-Aug-00	3:30 AM	4.9	5.3	6.4	6.7	665.49	7.2	0.925
21-Aug-00	4:00 AM	5.1	5.8	5.5	6.7	665.73	7	0.925
21-Aug-00	4:30 AM	5.1	5.1	5.5	6.7	665.91	6.9	0.925
21-Aug-00	5:00 AM	4.8	5.6	5.4	6.7	666.15	6.5	0.925
21-Aug-00	5:30 AM	4.7	5.4	5.4	6.7	666.35	5.4	0.925
21-Aug-00	6:00 AM	6.2	5.2	5.3	6.7	666.55	4.8	0.925
21-Aug-00	6:30 AM	7.1	6.5	5.3	6.7	666.86	4.3	0.925
21-Aug-00	7:00 AM	6.1	6.9	6.7	6.7	667.2	4.9	0.925
21-Aug-00	7:30 AM	6.2	6.4	6.7	6.7	667.49	7.1	0.926
21-Aug-00	8:00 AM	4	5.1	5.7	6.8	667.67	9.1	0.926
21-Aug-00	8:30 AM	8.3	7.1	5.7	6.8	668.03	12.7	0.926
21-Aug-00	9:00 AM	1.7	2	4.6	6.8	667.95	13.1	0.926
21-Aug-00	9:30 AM	4.2	6.6	4.6	6.8	668.26	12.8	0.926
21-Aug-00	10:00 AM	6.2	6.3	6.4	6.9	668.55	13.4	0.927
21-Aug-00	10:30 AM	7.1	7.2	6.4	6.9	668.92	17.1	0.927
21-Aug-00	11:00 AM	8	6.8	7	7	669.26	17.2	0.927
21-Aug-00	11:30 AM	18.7	14.1	7	7	670.24	22.2	0.927
21-Aug-00	12:00 PM	11.6	7.8	11	7.2	670.65	20.1	0.927
21-Aug-00	12:30 PM	0	1	11	7.2	670.48	25.2	0.927
21-Aug-00	1:00 PM	5.2	1.6	1.3	7.1	670.37	22.2	0.927
21-Aug-00	1:30 PM	5.6	8.5	1.3	7.1	670.83	22.4	0.927
21-Aug-00	2:00 PM	14.8	9.5	9	7.3	671.41	22.5	0.927
21-Aug-00	2:30 PM	12.7	9.6	9	7.3	671.98	23.4	0.927
21-Aug-00	3:00 PM	11	10.3	9.9	7.5	672.62	28.3	0.927
21-Aug-00	3:30 PM	5.5	4.7	9.9	7.5	672.77	29.8	0.927
21-Aug-00	4:00 PM	5.4	5.9	5.3	7.5	673.01	28.7	0.927
21-Aug-00	4:30 PM	9.2	9.5	5.3	7.5	673.59	29.6	0.927
21-Aug-00	5:00 PM	16.9	13	11.3	7.7	674.47	24.3	0.927
21-Aug-00	5:30 PM	8.5	9.6	11.3	7.7	675.04	24.7	0.926
21-Aug-00	6:00 PM	11	10.1	9.9	7.8	675.67	20.4	0.926
21-Aug-00	6:30 PM	12.5	11.5	9.9	7.8	676.41	19.6	0.926
21-Aug-00	7:00 PM	17.6	15.8	13.6	8	677.53	17.7	0.926
21-Aug-00	7:30 PM	83.7	31.5	13.6	8	680.07	17	0.926
21-Aug-00	8:00 PM	15.1	25.6	28.6	8.9	682	14.8	0.926
21-Aug-00	8:30 PM	71.6	36.2	28.6	8.9	684.94	13.7	0.926
21-Aug-00	9:00 PM	34.7	56.2	46.2	10.4	689.56	12.4	0. 926
21-Aug-00	9:30 PM	35	39.1	46.2	10.4	692.71	11.7	0.926
21-Aug-00	10:00 PM	25	27.1	33.1	11.3	694.82	12.5	0.926
21-Aug-00	10:30 PM	21.5	20.8	33.1	11.3	696.37	11.5	0.926
21-Aug-00	11:00 PM	20.4	19.6	20.2	11.6	697.82	10.5	0.926
21-Aug-00	11:30 PM	18.1	19.3	20.2	11.6	699.24	9.5	0.926
22-Aug-00	12:00 AM	18.1	18.8	19.1	11.9	700.62	8	0.926
22-Aug-00	12:30 AM	21.5	21.6	19.1	11.9	702.25	7.4	0.926
22-Aug-00	1:00 AM	21.8	22	21.8	12.5	703.91	7.9	0.926
22-Aug-00	1:30 AM	18.8	20.3	21.8	12.5	705.42	7.7	0.926
22-Aug-00	2:00 AM	14.6	16.2	18.3	13	706.57	7.6	0.926

22-Aug-00	2:30 AM	11.9	13.7	18.3	13	707.51	8	0.926
22-Aug-00	3:00 AM	11	11.6	12.7	13.2	708.26	6.4	0.926
22-Aug-00	3:30 AM	9.9	10.7	12.7	13.2	708.93	6.2	0.925
22-Aug-00	4:00 AM	8.2	9.1	9.9	13.4	709.46	6.3	0.925
22-Aug-00	4:30 AM	7.3	8.1	9.9	13.4	709.91	6.4	0.925
22-Aug-00	5:00 AM	6.3	6.8	7.5	13.5	710.24	6.1	0.925
22-Aug-00	5:30 AM	5.3	6	7.5	13.5	710.5	5.8	0.925
22-Aug-00	6:00 AM	7.1	6.6	6.3	13.6	710.82	4.7	0.925
22-Aug-00	6:30 AM	9.5	9.8	6.3	13.6	711.42	4.8	0.925
22-Aug-00	7:00 AM	7.9	9.9	9.9	13.7	712.02	6	0.925
22-Aug-00	7:30 AM	19.7	11.6	9.9	13.7	712.78	10	0.925
22-Aug-00	8:00 AM	9.9	17.1	14.3	14	714.01	13.2	0.925
22-Aug-00	8:30 AM	13.7	11.6	14.3	14	714.76	16.1	0.925
22-Aug-00	9:00 AM	13.1	14.6	13.1	14.4	715.78	19.2	0.926
22-Aug-00	9:30 AM	8	10.1	13.1	14.4	716.39	21.9	0.926
22-Aug-00	10:00 AM	14.1	9.8	10	14.5	716.99	23	0.926
22-Aug-00	10:30 AM	10.6	11.4	10	14.5	717.72	24	0.926
22-Aug-00	11:00 AM	16.6	9.5	10.5	14.7	718.3	24.8	0.927
22-Aug-00	11:30 AM	7.5	10.4	10.5	14.7	718.94	26	0.927
22-Aug-00	12:00 PM	7.5	12.7	11.6	14.7	719.78	26.4	0.926
22-Aug-00	12:30 PM	11.8	12.3	11.6	14.7	720.59	27.9	0.926
22-Aug-00	1:00 PM	19.4	12.3	12.3	15.2	721.42	28.3	0.926
22-Aug-00	1:30 PM	16.2	16.9	12.3	15.2	722.63	27.1	0.926
22-Aug-00	2:00 PM	10.5	12.9	14.9	15.4	723.49	27.4	0.925
22-Aug-00	2:30 PM	12.8	19.2	14.9	15.4	724.9	27.2	0.925
22-Aug-00	3:00 PM	15.1	16	17.6	15.7	726.04	29	0.925
22-Aug-00	3:30 PM	18.8	14.6	17.6	15.7	727.06	31.2	0.925
22-Aug-00	4:00 PM	11.5	16.1	15.3	16.2	728.19	31.1	0.925
22-Aug-00	4:30 PM	17.8	17.5	15.3	16.2	729.47	31.2	0.924
22-Aug-00	5:00 PM	18.3	17.4	17.5	16.4	730.72	25.7	0.924
22-Aug-00	5:30 PM	16.1	19.1	17.5	16.4	732.13	27.1	0.923
22-Aug-00	6:00 PM	24.2	20.4	19.8	16.8	733.66	23.8	0.923
22-Aug-00	6:30 PM	17.3	21.5	19.8	16.8	735.27	23.7	0.923
22-Aug-00	7:00 PM	29	25.1	23.3	17.2	737.21	22.7	0.922
22-Aug-00	7:30 PM	43.2	38.2	23.3	17.2	740.3	22.3	0.922
22-Aug-00	8:00 PM	43.7	41.5	39.9	17.7	743.66	20.1	0.922
22-Aug-00	8:30 PM	42.2	35.5	39.9	17.7	746.5	18.3	0.922
22-Aug-00	9:00 PM	45.3	46.8	41.2	17.5	750.33	17.1	0.922
22-Aug-00	9:30 PM	42.7	53.1	41.2	17.5	754.71	15.8	0.922
22-Aug-00	10:00 PM	39.2	46	49.6	18.2	758.46	14.6	0.923
22-Aug-00	10:30 PM	32.4	35.1	49.6	18.2	761.28	14.2	0.922
22-Aug-00	11:00 PM	25.5	29.9	32.5	18.7	763.62	13.8	0.922
22-Aug-00	11:30 PM	27.2	29.3	32.5	18.7	765.93	13.4	0.922
23-Aug-00	12:00 AM	26.2	25.9	27.6	19	767.92	12.8	0.922
23-Aug-00	12:30 AM	23.4	26.4	27.6	19	769.97	11.5	0.922
23-Aug-00	1:00 AM	22.2	23.4	24.9	19.2	771.75	11.2	0.922
23-Aug-00	1:30 AM	23.3	22.7	24.9	19.2	773.48	11	0.922
23-Aug-00	2:00 AM	27.5	25.9	24.3	19.4	775.48	9.5	0.922
23-Aug-00	2:30 AM	23.6	26.2	24.3	19.4	777.5	9.3	0.922
23-Aug-00	3:00 AM	21.3	21.9	24	19.9	779.15	8.8	0.922
23-Aug-00	3:30 AM	20.1	22.1	24	19.9	780.81	8.3	0.922
23-Aug-00	4:00 AM	22.5	22.3	22.2	20.4	782.5	8.4	0.922
23-Aug-00	4:30 AM	18.6	21	22.2	20.4	784.08	8.3	0.923
23-Aug-00	5:00 AM	14.5	16.6	18.8	20.9	785.26	7.6	0.923
23-Aug-00	5:30 AM	17.9	17.6	18.8	20.9	786.55	7.6	0.923
23-Aug-00	6:00 AM	19.8	17.9	17.8	21.4	787.85	7.8	0.923
23-Aug-00	6:30 AM	18.5	19	17.8	21.4	789.24	7.7	0.923
23-Aug-00	7:00 AM	24.3	19.9	19.5	21.8	790.73	8.3	0.924
23-Aug-00	7:30 AM	16.1	21.5	19.5	21.8	792.34	10	0.924
23-Aug-00	8:00 AM	20.9	21.5	21.5	22.1	793.95	13.2	0.924
23-Aug-00	8:30 AM	17.4	16.3	21.5	22.1	795.12	17.6	0.924
23-Aug-00	9:00 AM	16.9	19.5	17.9	22.3	796.55	20.6	0.925

23-Aug-00	9:30 AM	19.6	23.4	17.9	22.3	798.34	23	0.925
23-Aug-00	10:00 AM	31.6	30.5	26.9	23	800.74	21.3	0.926
23-Aug-00	10:30 AM	23.9	24.2	26.9	23	802.6	24.5	0.926
23-Aug-00	11:00 AM	22	22.7	23.4	23.5	804.31	27.5	0.927
23-Aug-00	11:30 AM	11.7	15.8	23.4	23.5	805.43	29.9	0.927
23-Aug-00	12:00 PM	13.7	23.1	22.1	23.5	806.55	30	0.927
Average		10.93	11.12	11.11	10.91		16.09	
Std Dev		7.88	7.46	7.21	4.35		7.06	

Date	Time	Mass Concentration (μg/m³)	30-min Concentration (μg/m³)	1-hr Concentration (μg/m³)	24-hr Concentration (μg/m³)	Total Mass (μg)	Temperature (°C)	Pressure (atm)
03-Oct-00	12:00 PM	1.4	6.7	4.1	6.2	16.35	4.8	0.933
03-Oct-00	12:30 PM	0.6	0	4.1	6.2	16.45	5.4	0.932
03-Oct-00	1:00 PM	1.2	1.1	0.4	6.3	16.55	6.8	0.932
03-Oct-00	1:30 PM	2.2	1.8	0.4	6.3	16.65	7.8	0.932
03-Oct-00	2:00 PM	3.4	1.9	1.8	5.8	16.75	7.8	0.932
03-Oct-00	2:30 PM	3.8	3.6	1.8	5.8	16.81	2.2	0.931
03-Oct-00	3:00 PM	4.2	4.4	4	5.4	16.93	2.9	0.931
03-Oct-00	3:30 PM	2	0	4	5.4	16.63	8.3	0.931
03-Oct-00	4:00 PM	5	3.6	1.5	5.1	16.68	5.2	0.93
03-Oct-00	4:30 PM	3.9	4.1	1.5	5.1	16.78	10.9	0.93
03-Oct-00	5:00 PM	2.1	2.6	3.4	4.9	16.74	4	0.929
03-Oct-00	5:30 PM	0	2.4	3.4	4.9	16.69	1.6	0.929
03-Oct-00	6:00 PM	4.6	3.8	3.1	4.7	16.76	1.6	0.929
03-Oct-00	6:30 PM	0.4	4.3	3.1	4.7	16.87	0.5	0.929
03-Oct-00	7:00 PM	7.1	5.3	4.8	4.5	17.08	0	0.929
03-Oct-00	7:30 PM	0.6	3.8	4.8	4.5	17.14	-0.6	0.929
03-Oct-00	8:00 PM	6.1	6.3	5	4.4	17.43	-0.7	0.929
03-Oct-00	8:30 PM	4.6	3.3	5	4.4	17.46	-0.9	0.929
03-Oct-00	9:00 PM	6.8	6.7	5	4.4	17.78	-1.4	0.929
03-Oct-00	9:30 PM	7	4.5	5	4.4	17.92	-2.3	0.929
03-Oct-00	10:00 PM	3.2	5.3	4.9	4.4	18.12	-2.9	0.929
03-Oct-00	10:30 PM	8.1	6.6	4.9	4.4	18.43	-3.3	0.929
03-Oct-00	11:00 PM	5.2	2.8	4.7	4.4	18.42	-3.7	0.929
03-Oct-00	11:30 PM	3.2	2.7	4.7	4.4	18.39	-3.8	0.928
04-Oct-00	12:00 AM	0	2.8	2.8	4.4	18.37	-4.1	0.928
04-Oct-00	12:30 AM	0.1	3.6	2.8	4.4	18.42	-4.3	0.929
04-Oct-00	1:00 AM	5.4	3.9	3.7	4.4	18.5	-4.4	0.929
04-Oct-00	1:30 AM	4.8	2.1	3.7	4.4	18.42	-4.4	0.929
04-Oct-00	2:00 AM	1.3	2.4	2.2	4.3	18.36	-4.4	0.93
04-Oct-00	2:30 AM	0	2.9	2.2	4.3	18.36	-4.3	0.93
04-Oct-00	3:00 AM	1.3	4.6	3.8	4.3	18.49	-4.5	0.931
04-Oct-00	3:30 AM	6.4	3	3.8	4.3	18.51	-4.7	0.931
04-Oct-00	4:00 AM	4.1	1.9	2.5	4.2	18.41	-5.3	0.931
04-Oct-00	4:30 AM	2.7	3.2	2.5	4.2	18.43	-5.9	0.932
04-Oct-00	5:00 AM	0	4.2	3.7	4.3	18.53	-7	0.932
04-Oct-00	5:30 AM	5.9	5.9	3.7	4.3	18.78	-7.6	0.932
04-Oct-00	6:00 AM	7.4	2.6	4.2	4.3	18.75	-7.8	0.933
04-Oct-00	6:30 AM	5.6	3	4.2	4.3	18.75	-8.4	0.933
04-Oct-00	7:00 AM	3.4	2.3	2.7	4.2	18.69	-8.8	0.933
04-Oct-00	7:30 AM	4	3.6	2.7	4.2	18.74	-9.4	0.933
04-Oct-00	8:00 AM	3.7	4.5	4	4.2	18.87	-8.5	0.933
04-Oct-00	8:30 AM	0.5	4.3	4	4.2	18.98	-5.5	0.933
04-Oct-00	9:00 AM	0.7	4.8	4.5	4.1	19.13	-5.1	0.934
04-Oct-00	9:30 AM	7.7	5.4	4.5	4.1	19.35	-3.9	0.934
04-Oct-00	10:00 AM	6.5	3.4	4.4	4.1	19.39	-2	0.934
04-Oct-00	10:30 AM	0.7	4.2	4.4	4.1	19.49	-3.1	0.934
04-Oct-00	11:00 AM	6.3	5.7	5	4.4	19.73	-0.6	0.935
04-Oct-00	11:30 AM	5.5	3	5	4.4	19.73	-1.1	0.935
04-Oct-00	12:00 PM	2.6	5.2	4.1	3.6	19.92	-2.7	0.935
04-Oct-00	12:30 PM	6	4.2	4.1	3.6	20.03	0.1	0.935
04-Oct-00	1:00 PM	4.2	2.9	3.6	3.7	20.02	-1.2	0.935
04-Oct-00	1:30 PM	1.9	4.8	3.6	3.7	20.17	-2.6	0.935
04-Oct-00	2:00 PM	5.8	4.8	4.8	3.9	20.33	-1.4	0.935
04-Oct-00	2:30 PM	7.3	3.7	4.8	3.9	20.38	-2	0.935
04-Oct-00	3:00 PM	0	3.5	3.6	3.8	20.42	-0.6	0.935
04-Oct-00	3:30 PM	8.4	4.8	3.6	3.8	20.59	-1.9	0.935
04-Oct-00	4:00 PM	4.7	2.8	3.8	3.9	20.57	-0.1	0.935
04-Oct-00	4:30 PM	0	2.4	3.8	3.9	20.5	-1.4	0.935
04-Oct-00	5:00 PM	4.9	3	2.7	3.9	20.51	-0.7	0.935

04-Oct-00	5:30 PM	2.3	1.8	2.7	3.9	20.4	-1.9	0.935
04-Oct-00	6:00 PM	0	3.4	2.6	3.9	20.44	-2.8	0.935
04-Oct-00	6:30 PM	6.4	4.7	2.6	3.9	20.59	-4.2	0.935
04-Oct-00	7:00 PM	5.6	2.6	3.7	3.8	20.56	-5.6	0.935
04-Oct-00	7:30 PM	4	3.7	3.7	3.8	20.62	-7.3	0.935
04-Oct-00	8:00 PM	0	4.1	3.9	3.8	20.71	-8.3	0.935
04-Oct-00	8:30 PM	7.9	7.1	3.9	3.8	21.07	-8.4	0.935
04-Oct-00	9:00 PM	6	2.7	4.9	3.8	21.05	-9	0.935
04-Oct-00	9:30 PM	3.9	2.5	4.9	3.8	21	-8.6	0.935
04-Oct-00	10:00 PM	0.9	3.6	3	3.7	21.05	-7.3	0.935
04-Oct-00	10:30 PM	0	3.7	3	3.7	21.1	-8.5	0.935
04-Oct-00	11:00 PM	3.3	4.7	4.2	3.7	21.25	-8.2	0.935
04-Oct-00	11:30 PM	7	3.9	4.2	3.7	21.33	-8.9	0.935
05-Oct-00	12:00 AM	6.3	3.2	3.5	3.7	21.35	-9.1	0.935
05-Oct-00	12:30 AM	4.9	3.1	3.5	3.7	21.36	-8.7	0.935
05-Oct-00	1:00 AM	5.1	2.7	2.9	3.7	21.33	-8.6	0.935
05-Oct-00	1:30 AM	3.6	3.4	2.9	3.7	21.36	-8.7	0.935
05-Oct-00	2:00 AM	3.9	3.6	3.5	3.7	21.41	-9.2	0.935
05-Oct-00	2:30 AM	4.1	3.5	3.5	3.7	21.45	-9.7	0.936
05-Oct-00	3:00 AM	3	3.3	3.4	3.7	21.48	-9.4	0.936
05-Oct-00	3:30 AM	3	3	3.4	3.7	21.48	-10.1	0.936
05-Oct-00	4:00 AM	2.5	3.5	3.3	3.7	21.53	-10.1	0.936
05-Oct-00	4:30 AM	2.3	3.2	3.3	3.7	21.54	-9.8	0.936
05-Oct-00	5:00 AM	2.6	3.1	3.1	3.7	21.55	-10.2	0.936
05-Oct-00	5:30 AM	3.1	4.2	3.1	3.7	21.65	-10.2	0.936
05-Oct-00	6:00 AM	3	3.3	3.8	3.7	21.67	-10.2	0.936
05-Oct-00	6:30 AM	4.1	3.8	3.8	3.7	21.74	-10.5	0.936
05-Oct-00	7:00 AM	4.6	3.9	3.8	3.7	21.82	-10.7	0.936
05-Oct-00	7:30 AM	5.5	4.2	3.8	3.7	21.93	-11	0.936
05-Oct-00	8:00 AM	6.6	4.6	4.4	3.8	22.07	-10.5	0.936
05-Oct-00	8:30 AM	6.4	4.8	4.4	3.8	22.22	-8.4	0.936
05-Oct-00	9:00 AM	5.4	4.3	4.5	3.8	22.33	-6.6	0.937
05-Oct-00	9:30 AM	4.1	4.4	4.5	3.8	22.45	-4.9	0.937
05-Oct-00	10:00 AM	1.7	5.9	5.1	3.8	22.7	-2.1	0.938
05-Oct-00	10:30 AM	6.7	4.2	5.1	3.8	22.81	-0.2	0.938
05-Oct-00	11:00 AM	6.9	6.8	5.5	3.8	23.14	3	0.938
05-Oct-00	11:30 AM	3	5.4	5.5	3.8	23.35	5	0.939
05-Oct-00	12:00 PM	2.7	2.7	4	3.8	23.32	6	0.939
05-Oct-00	12:30 PM	6.6	6.2	4	3.8	23.6	9.6	0.939
05-Oct-00	1:00 PM	0	0	2.8	3.8	23.28	8.8	0.939
05-Oct-00	1:30 PM	0	0	2.8	3.8	23	9	0.939
05-Oct-00	2:00 PM	5.8	3.1	1.5	3.6	23.02	7.7	0.939
05-Oct-00	2:30 PM	6.7	5.9	1.5	3.6	23.27	2.5	0.939
05-Oct-00	3:00 PM	6.5	7.2	6.5	3.8	23.64	1.9	0.938
05-Oct-00	3:30 PM	3.4	1.6	6.5	3.8	23.51	7.7	0.938
05-Oct-00	4:00 PM	5.9	5.3	3.4	3.8	23.71	11.2	0.938
05-Oct-00	4:30 PM	5.2	5.5	3.4	3.8	23.94	11.7	0.939
05-Oct-00	5:00 PM	6.2	5.8	5.7	3.9	24.18	6.9	0.938
05-Oct-00	5:30 PM	5.9	6	5.7	3.9	24.44	1.5	0.938
05-Oct-00	6:00 PM	5.4	2.5	4.2	3.9	24.39	-0.7	0.938
05-Oct-00	6:30 PM	7.7	7.8	4.2	3.9	24.81	-1.9	0.938
05-Oct-00	7:00 PM	6.1	2.2	5	4	24.74	-3.1	0.938
05-Oct-00	7:30 PM	1.7	5.1	5	4	24.93	-3.5	0.937
05-Oct-00	8:00 PM	10.2	9.4	7.3	4.1	25.49	-4.8	0.937
05-Oct-00	8:30 PM	11.5	7	7.3	4.1	25.85	-5.9	0.937
05-Oct-00	9:00 PM	3	9.7	8.4	4.3	26.43	-5.9	0.937
05-Oct-00	9:30 PM	10.6	8.7	8.4	4.3	26.93	-6.3	0.937
05-Oct-00	10:00 PM	9.3	6.5	7.6	4.5	27.23	-6.1	0.937
05-Oct-00	10:30 PM	8.2	7.2	7.6	4.5	27.6	-7.9	0.937
05-Oct-00	11:00 PM	10.5	13	10.1	4.7	28.48	-8.1	0.937
05-Oct-00	11:30 PM	4.6	12	10.1	4.7	29.26	-8.9	0.937
06-Oct-00	12:00 AM	8.3	8.1	10.1	5	29.71	-8.7	0.937

224

06-Oct-00	12:30 AM	8.8	5.1	10.1	5	29.89	-9.2	0.937
06-Oct-00	1:00 AM	7.2	4.3	4.7	5.1	30.01	-9.2	0.936
06-Oct-00	1:30 AM	6.3	3.9	4.7	5.1	30.08	-9.1	0.937
06-Oct-00	2:00 AM	4.1	3.3	3.6	5.1	30.11	-9.4	0.937
06-Oct-00	2:30 AM	1.7	3.2	3.6	5.1	30.13	-10.1	0.937
06-Oct-00	3:00 AM	0	4	3.6	5.1	30.22	-10.3	0.937
06-Oct-00	3:30 AM	0	3.7	3.6	5.1	30.28	-10.8	0.937
06-Oct-00	4:00 AM	6.2	5.8	4.8	5.1	30.52	-10	0.937
06-Oct-00	4:30 AM	6.8	3.5	4.8	5.1	30.57	-11	0.936
06-Oct-00	5:00 AM	8.1	3.7	3.6	5.2	30.63	-11.2	0.936
06-Oct-00	5:30 AM	6.8	4.2	3.6	5.2	30.73	-11	0.936
06-Oct-00	6:00 AM	7.8	4.1	4.1	5.2	30.82	-10.6	0.936
06-Oct-00	6:30 AM	7.9	4.3	4.1	5.2	30.94	-10.6	0.936
06-Oct-00	7:00 AM	6.5	4	4.1	5.2	31.02	-10.2	0.936
06-Oct-00	7:30 AM	7.7	5.3	4.1	5.2	31.22	-10.2	0.936
06-Oct-00	8:00 AM	10.5	7.6	6.5	5.3	31.63	-9.6	0.936
06-Oct-00	8:30 AM	10.2	7.6	6.5	5.3	32.03	-7.6	0.936
06-Oct-00	9:00 AM	7.4	6.4	7	5.4	32.32	-5.5	0.936
06-Oct-00	9:30 AM	6.2	5.6	7	5.4	32.55	-4.3	0.937
06-Oct-00	10:00 AM	3	6.9	6.2	5.4	32.89	-1.5	0.937
06-Oct-00	10:30 AM	7.4	7.9	6.2	5.4	33.32	0.7	0.938
06-Oct-00	11:00 AM	2.6	2.4	5.1	5.4	33.26	2.6	0.938
06-Oct-00	11:30 AM	6.9	6.6	5.1	5.4	33.58	4	0.938
06-Oct-00	12:00 PM	13.8	9	7.8	5.6	34.12	4.4	0.938
06-Oct-00	12:30 PM	0	8.1	6.7	5.5	34.15	5.4	0.938
06-Oct-00	1:00 PM	0	6.7	5.3	5.5	34.18	6.7	0.939
06-Oct-00	1:30 PM	0	5.4	4.2	5.5	34.21	6.9	0.939
06-Oct-00	2:00 PM	0	0	3.9	5.6	34.24	6.3	0.939
06-Oct-00	2:30 PM	0	3.2	2.6	5.6	34.27	4.7	0.939
06-Oct-00	3:00 PM	3.6	0	1.2	5.6	34.3	4.9	0.939
06-Oct-00	3:30 PM	5.5	6.5	1.2	5.6	34.33	8.6	0.939
06-Oct-00	4:00 PM	2.2	0.3	3.4	5.5	34.36	9.2	0.939
06-Oct-00	4:30 PM	6.8	5.8	3.4	5.4	34.39	9.1	0.939
06-Oct-00	5:00 PM	8.3	7.6	6.7	5.4	34.42	6.9	0.938
06-Oct-00	5:30 PM	0	4.8	6.7	5.5	34.45	3.9	0.938
06-Oct-00	6:00 PM	8.7	7.6	6.2	5.5	34.48	3.1	0.938
06-Oct-00	6:30 PM	2.9	6.7	6.2	5.5	34.51	2.3	0.937
06-Oct-00	7:00 PM	24.6	13	9.8	5.6	34.54	1.1	0.937
06-Oct-00	7:30 PM	7.2	4.9	9.8	5.7	34.57	0.1	0.937
06-Oct-00	8:00 PM	1	11.1	8	5.8	35.04	-0.4	0.937
06-Oct-00	8:30 PM	22.9	10.1	8	5.9	35.69	-0.8	0.936
06-Oct-00	9:00 PM	5.9	2.6	6.4	5.9	35.63	-0.9	0.936
06-Oct-00	9:30 PM	1.1	5.5	6.4	5.8	35.85	-1.2	0.936
06-Oct-00	10:00 PM	0	6.7	6.1	5.8	36.16	-1.7	0.935
06-Oct-00	10:30 PM	26.3	8.4	6.1	5.8	36.66	-1.5	0.935
06-Oct-00	11:00 PM	6.5	0.6	4.5	5.7	36.43	-1.8	0.935
06-Oct-00	11:30 PM	1.8	4	4.5	5.7	36.52	-2.4	0.935
07-Oct-00	12:00 AM	0	4.5	4.3	5.6	36.65	-2.6	0.934
07-Oct-00	12:30 AM	0.4	6.6	4.3	5.4	36.96	-2.9	0.934
07-Oct-00	1:00 AM	10	1.2	3.9	5.3	36.83	-3	0.934
07-Oct-00	1:30 AM	3.3	1.8	3.9	5.2	36.7	-3	0.934
07-Oct-00	2:00 AM	0	2.5	2.1	5.2	36.66	-2.5	0.934
07-Oct-00	2:30 AM	0	4.1	2.1	5.1	36.75	-2.8	0.933
07-Oct-00	3:00 AM	6	7	5.6	5.1	37.09	-3	0.933
07-Oct-00	3:30 AM	4.1	0	5.6	5.1	36.78	-3.6	0.933
07-Oct-00	4:00 AM	2	2.3	0.8	5.2	36.72	-3.8	0.932
07-Oct-00	4:30 AM	0	3.1	0.8	5.1	36.73	-3.7	0.932
07-Oct-00	5:00 AM	0	3.7	3.4	5.0	36.78	-3.9	0.932
07-Oct-00	5:30 AM	0	4.5	3.4	5.0	36.91	-4.1	0.931
07-Oct-00	6:00 AM	13.4	6.1	5.3	5.0	37.18	-4	0.931
07-Oct-00	6:30 AM	23.9	1.6	5.3	5.0	37.12	-4.1	0.931
07-Oct-00	7:00 AM	2.1	0	0.4	5.1	36.74	-4.7	0.931

225

07-Oct-00	7:30 AM	0.1	3.4	0.4	5.0	36.78	-4.9	0.93
07-Oct-00	8:00 AM	0	4.4	3.9	4.9	36.9	-4.6	0.93
07-Oct-00	8:30 AM	0	4.3	3.9	4.9	37.01	-3	0.93
07-Oct-00	9:00 AM	0	6.1	5.2	4.8	37.27	-1.4	0.93
07-Oct-00	9:30 AM	27.5	10.1	5.2	4.8	37.9	0.1	0.93
07-Oct-00	10:00 AM	2.3	0	3.6	4.8	37.38	2	0.93
07-Oct-00	10:30 AM	0	8.3	3.6	4.7	37.83	4	0.93
07-Oct-00	11:00 AM	5.3	8	4.7	4.7	37.67	5.8	0.93
07-Oct-00	11:30 AM	6.9	6.1	4.7	4.6	37.94	7.5	0.93
07-Oct-00	12:00 PM	0	10.1	11.2	4.6	36.4	8.8	0.93
07-Oct-00	12:30 PM	15.8	12.7	11.4	4.7	37.36	10.8	0.929
07-Oct-00	1:00 PM	13.7	13.7	13.2	4.8	38.29	11.9	0.929
07-Oct-00	1:30 PM	14.6	13.5	13.2	5.0	39.21	12.4	0.929
07-Oct-00	2:00 PM	12.7	13.5	13.5	4.9	40.13	12.1	0.929
07-Oct-00	2:30 PM	15.8	17.1	13.5	4.9	41.36	10.9	0.929
07-Oct-00	3:00 PM	16.4	16.3	16.7	5.6	42.52	11.4	0.929
07-Oct-00	3:30 PM	16.5	15.6	16.7	5.6	43.62	14.5	0.929
07-Oct-00	4:00 PM	18.4	20	17.8	6.2	45.1	15.5	0.929
07-Oct-00	4:30 PM	14.6	14.7	17.8	6.2	46.13	12.8	0.929
07-Oct-00	5:00 PM	17.3	17.1	15.9	6.6	47.36	11.1	0.929
07-Oct-00	5:30 PM	20.7	23.4	15.9	6.6	49.15	10.4	0.928
07-Oct-00	6:00 PM	15.9	21.9	22.6	7.2	50.79	10.3	0.928
07-Oct-00	6:30 PM	23.1	21.3	22.6	7.2	52.39	8.8	0.928
07-Oct-00	7:00 PM	12.7	16.9	19.1	7.6	53.61	6.9	0.928
07-Oct-00	7:30 PM	26.4	26.3	19.1	7.6	55.65	5.6	0.927
07-Oct-00	8:00 PM	24.1	26.5	26.4	8.4	57.7	4.5	0.927
07-Oct-00	8:30 PM	24.6	22.5	26.4	8.4	59.4	4	0.926
07-Oct-00	9:00 PM	24.2	22.6	22.5	9.1	61.12	3.1	0.926
07-Oct-00	9:30 PM	20	19.1	22.5	9.1	62.53	2.9	0.926
07-Oct-00	10:00 PM	27.2	26.5	22.8	9.8	64.59	3.1	0.925
07-Oct-00	10:30 PM	22.3	22.5	22.8	9.8	66.29	3	0.925
07-Oct-00	11:00 PM	39.2	30.8	26.6	10.7	68.7	2.6	0.924
07-Oct-00	11:30 PM	20	12.1	26.6	10.7	69.51	1.3	0.924
08-Oct-00	12:00 AM	13.7	23.5	17.8	11.3	71.3	0.9	0.924
08-Oct-00	12:30 AM	23	26.8	17.8	11.3	73.39	0.6	0.924
08-Oct-00	1:00 AM	19.7	19.5	23.2	12.1	74.84	0.3	0.924
08-Oct-00	1:30 AM	37.4	28.9	23.2	12.1	77.09	-0.7	0.923
08-Oct-00	2:00 AM	15.1	8	18.4	12.7	77.53	-0.3	0.923
08-Oct-00	2:30 AM	4.4	11.2	18.4	12.7	78.25	-0.6	0.923
08-Oct-00	3:00 AM	34.4	18.6	14.9	13.1	79.64	-1	0.922
08-Oct-00	3:30 AM	14.8	7.1	14.9	13.1	79.97	-1.8	0.922
08-Oct-00	4:00 AM	6.7	12.6	9.8	13.5	80.8	-2.1	0.922
08-Oct-00	4:30 AM	9.7	16.1	9.8	13.5	81.93	-3	0.922
08-Oct-00	5:00 AM	15.6	8.4	12.2	13.9	82.42	-2.8	0.922
08-Oct-00	5:30 AM	9	8.9	12.2	13.9	82.93	-2.9	0.921
08-Oct-00	6:00 AM	0	9.7	9.3	14	83.5	-3.5	0.921
08-Oct-00	6:30 AM	12.7	10.3	9.3	14	84.15	-4.8	0.921
08-Oct-00	7:00 AM	10.7	7.2	8.8	14.4	84.52	-4.2	0.921
08-Oct-00	7:30 AM	1.8	8.9	8.8	14.4	85.03	-4	0.921
08-Oct-00	8:00 AM	5.6	14.1	11.5	14.7	85.99	-4.5	0.921
08-Oct-00	8:30 AM	14.4	7.9	11.5	14.7	86.44	-1.6	0.921
08-Oct-00	9:00 AM	12.6	10.9	9.4	14.9	87.12	1.8	0.921
08-Oct-00	9:30 AM	15	15.1	9.4	14.9	88.18	4.6	0.921
08-Oct-00	10:00 AM	12.1	12.3	13.7	15.3	88.99	6.9	0.921
08-Oct-00	10:30 AM	10.9	12.4	13.7	15.3	89.82	9.4	0.922
08-Oct-00	11:00 AM	12.1	13.7	13.1	15.7	90.75	13.2	0.922
08-Oct-00	11:30 AM	11.2	11.9	13.1	15.7	91.53	15.4	0.923
08-Oct-00	12:00 PM	10.4	11.5	11.7	16.3	92.27	17	0.923
08-Oct-00	12:30 PM	10.1	9	11.7	16.3	92.79	20.9	0.922
08-Oct-00	1:00 PM	6.4	7.7	8.3	16.1	93.2	22.5	0.922
08-Oct-00	1:30 PM	12.2	11.1	8.3	16.1	93.91	21.5	0.923
08-Oct-00	2:00 PM	12	10.7	10.9	16	94.59	23.5	0.923

08-Oct-00	2:30 PM	14.6	13.9	10.9	16	95.54	18.8	0.923
08-Oct-00	3:00 PM	16.8	16.6	15.3	15.9	96.73	19	0.923
08-Oct-00	3:30 PM	9	13.8	15.3	15.9	97.67	24.7	0.923
08-Oct-00	4:00 PM	13.3	13.3	13.5	15.7	98.57	28.3	0.923
08-Oct-00	4:30 PM	18.7	13.7	13.5	15.7	99.51	28.6	0.923
08-Oct-00	5:00 PM	19.8	17.7	15.7	15.7	100.79	24.6	0.923
08-Oct-00	5:30 PM	26.9	24.3	15.7	15.7	102.65	18	0.923
08-Oct-00	6:00 PM	18.1	22.6	23.4	15.8	104.36	15.4	0.923
08-Oct-00	6:30 PM	22.4	17.8	23.4	15.8	105.66	14	0.923
08-Oct-00	7:00 PM	13.5	19.6	18.7	15.8	107.1	12.6	0.923
08-Oct-00	7:30 PM	17.9	14.9	18.7	15.8	108.14	10.5	0.923
08-Oct-00	8:00 PM	21	23.6	19.2	15.5	109.94	10.6	0.923
08-Oct-00	8:30 PM	28.4	23.6	19.2	15.5	111.74	9.8	0.923
08-Oct-00	9:00 PM	16.5	22.4	23	15.5	113.43	9.3	0.923
08-Oct-00	9:30 PM	17.4	17.3	23	15.5	114.69	8.2	0.923
08-Oct-00	10:00 PM	76.6	47.9	32.6	15.9	118.66	7.3	0.922
08-Oct-00	10:30 PM	53	68.7	32.6	15.9	124.35	6.8	0.922
08-Oct-00	11:00 PM	32.8	35.9	52.3	17	127.23	5.4	0.923
08-Oct-00	11:30 PM	22.5	25	52.3	17	129.14	5.3	0.923
09-Oct-00	12:00 AM	31.7	31.4	28.2	17.4	131.63	4.3	0.923
09-Oct-00	12:30 AM	27.3	25	28.2	17.4	133.54	4.4	0.923
09-Oct-00	1:00 AM	34.2	31.2	28.1	17.6	136.02	4.7	0.923
09-Oct-00	1:30 AM	31.6	32.8	28.1	17.6	138.61	4.5	0.923
09-Oct-00	2:00 AM	23.5	20.9	26.9	17.9	140.18	4.6	0.923
09-Oct-00	2:30 AM	24.1	23.9	26.9	17.9	142.01	4.8	0.923
09-Oct-00	3:00 AM	3.1	18.1	21	18.2	143.31	4.8	0.923
09-Oct-00	3:30 AM	21.3	19.2	21	18.2	144.74	3.8	0.923
09-Oct-00	4:00 AM	17.1	18.2	18.7	18.6	146.07	4.3	0.923
09-Oct-00	4:30 AM	9	11.2	18.7	18.6	146.78	5.3	0.923
09-Oct-00	5:00 AM	14.5	15.5	13.4	18.6	147.88	4	0.923
09-Oct-00	5:30 AM	29.4	17.2	13.4	18.6	149.16	3.9	0.923
09-Oct-00	6:00 AM	13	7.3	12.3	18.7	149.5	4	0.923
09-Oct-00	6:30 AM	13.8	15.3	12.3	18.7	150.57	3.2	0.923
09-Oct-00	7:00 AM	9.9	10.4	12.8	18.9	151.22	3.1	0.924
09-Oct-00	7:30 AM	13.8	13.8	12.8	18.9	152.17	2.5	0.924
09-Oct-00	8:00 AM	0	9	11.4	18.9	152.68	2.4	0.924
09-Oct-00	8:30 AM	10.9	11.4	11.4	18.9	153.43	2.4	0.924
09-Oct-00	9:00 AM	34.5	18.5	15	19.1	154.81	3.4	0.924
09-Oct-00	9:30 AM	16.1	5.8	15	19.1	155.04	4.3	0.923
09-Oct-00	10:00 AM	23.2	22.6	14.2	19.2	156.75	6.3	0.924
09-Oct-00	10:30 AM	15.6	18	14.2	19.2	158.06	7	0.924
09-Oct-00	11:00 AM	8.9	13.9	16	19.3	159.02	8.7	0.924
09-Oct-00	11:30 AM	22.9	20.6	16	19.3	160.56	9.7	0.924
09-Oct-00	12:00 PM	21.7	23.9	22.3	19.7	162.39	9.5	0.924
09-Oct-00	12:30 PM	20.1	23.3	22.3	19.7	164.15	11.3	0.924
09-Oct-00	1:00 PM	16.3	17.2	20.3	20.2	165.4	12	0.924
09-Oct-00	1:30 PM	16.8	17.4	20.3	20.2	166.66	13.3	0.924
09-Oct-00	2:00 PM	21.3	20.1	18.8	20.5	168.16	14.4	0.924
09-Oct-00	2:30 PM	20.8	21.6	18.8	20.5	169.78	14.2	0.924
09-Oct-00	3:00 PM	17.6	18.3	19.9	20.7	171.12	14.3	0.923
09-Oct-00	3:30 PM	17.3	17.9	19.9	20.7	172.42	13.9	0.923
09-Oct-00	4:00 PM	20.5	19.7	18.8	21	173.89	13.4	0.923
09-Oct-00	4:30 PM	24.9	22.6	18.8	21	175.6	13.3	0.923
09-Oct-00	5:00 PM	37.4	33.9	28.2	21.5	178.3	12	0.923
09-Oct-00	5:30 PM	32.8	31.1	28.2	21.5	180.75	10.2	0.923
09-Oct-00	6:00 PM	31.1	32.5	31.8	21.8	183.33	8.3	0.923
09-Oct-00	6:30 PM	32.4	27.8	31.8	21.8	185.5	6.9	0.922
09-Oct-00	7:00 PM	28.3	30	28.9	22.3	187.85	5.8	0.922
09-Oct-00	7:30 PM	12.8	29	28.9	22.3	190.1	5.2	0.922
09-Oct-00	8:00 PM	26.1	22.3	25.6	22.5	191.81	4.8	0.922
09-Oct-00	8:30 PM	29.2	27.6	25.6	22.5	193.96	4.1	0.922
09-Oct-00	9:00 PM	8.7	22.6	25.1	22.6	195.66	4.3	0.922

09-Oct-00	9:30 PM	24.5	22.9	25.1	22.6	197.41	3.6	0.922
09-Oct-00	10:00 PM	27.1	26.9	24.9	22.3	199.49	3.9	0.922
09-Oct-00	10:30 PM	23.9	21	24.9	22.3	201.07	3.4	0.922
09-Oct-00	11:00 PM	26.5	27	24	21.1	203.16	4.3	0.922
09-Oct-00	11:30 PM	11.8	25.5	24	21.1	205.11	3.4	0.921
10-Oct-00	12:00 AM	21.3	18.9	22.2	20.9	206.51	3.1	0.921
10-Oct-00	12:30 AM	22.9	23.9	22.2	20.9	208.34	1.9	0.921
10-Oct-00	1:00 AM	16.9	13.9	18.9	20.5	209.29	1.2	0.921
10-Oct-00	1:30 AM	17.8	17.7	18.9	20.5	210.58	0.7	0.921
10-Oct-00	2:00 AM	12.8	11.7	14.7	20	211.34	0.9	0.921
10-Oct-00	2:30 AM	16.4	15.2	14.7	20	212.41	0.5	0.92
10-Oct-00	3:00 AM	11.7	10	12.6	19.6	213.02	0.3	0.92
10-Oct-00	3:30 AM	28.1	17.2	12.6	19.6	214.3	-0.8	0.92
10-Oct-00	4:00 AM	13	6.2	11.7	19.3	214.54	-0.3	0.92
10-Oct-00	4:30 AM	0.1	13.5	11.7	19.3	215.43	-0.7	0.92
10-Oct-00	5:00 AM	14.1	7.8	10.6	19.2	215.87	-0.2	0.92
10-Oct-00	5:30 AM	0.3	10	10.6	19.2	216.48	0	0.92
10-Oct-00	6:00 AM	13.1	11.8	10.9	19.2	217.25	-0.1	0.92
10-Oct-00	6:30 AM	7.5	8.6	10.9	19.2	217.74	0.1	0.92
10-Oct-00	7:00 AM	13	12.9	10.8	19.1	218.61	0	0.92
10-Oct-00	7:30 AM	11	8.4	10.8	19.1	219.08	0.2	0.92
10-Oct-00	8:00 AM	18.6	18.6	13.5	19.2	220.43	1.1	0.921
10-Oct-00	8:30 AM	18.5	8.8	13.5	19.2	220.95	1.6	0.921
10-Oct-00	9:00 AM	29.5	20.6	14.7	19.1	222.48	2.3	0.921
10-Oct-00	9:30 AM	15	5.1	14.7	19.1	222.67	3.2	0.921
10-Oct-00	10:00 AM	18.1	17.5	11.3	19	223.94	5.3	0.921
10-Oct-00	10:30 AM	14.6	19.5	11.3	19	225.35	7.1	0.922
10-Oct-00	11:00 AM	13.1	6	12.7	18.9	225.63	8.6	0.922
10-Oct-00	11:30 AM	10.9	12.7	12.7	18.9	226.48	10.1	0.922
10-Oct-00	12:00 PM	11.8	11.9	12.3	18.5	227.26	11.6	0.922
10-Oct-00	12:30 PM	11.5	12.1	12.3	18.5	228.05	14.4	0.922
10-Oct-00	1:00 PM	9.8	10.2	11.1	18.1	228.68	16	0.922
10-Oct-00	1:30 PM	15.5	13.4	11.1	18.1	229.59	16.8	0.923
10-Oct-00	2:00 PM	14.7	13.6	13.5	17.9	230.52	16.5	0.923
10-Oct-00	2:30 PM	17.7	17.2	13.5	17.9	231.77	12.6	0.923
10-Oct-00	3:00 PM	18	19.6	18.4	17.8	233.21	12.9	0.923
10-Oct-00	3:30 PM	19.7	19.2	18.4	17.8	234.63	15	0.923
10-Oct-00	4:00 PM	19.6	18.9	19	17.8	236.02	16.9	0.923
10-Oct-00	4:30 PM	18.1	20	19	17.8	237.51	15.1	0.924
10-Oct-00	5:00 PM	20	18.9	19.5	17.4	238.9	14	0.924
10-Oct-00	5:30 PM	21.6	21.5	19.5	17.4	240.51	10.6	0.924
10-Oct-00	6:00 PM	16.5	17.7	19.6	16.9	241.79	9.1	0.925
10-Oct-00	6:30 PM	13.1	14.7	19.6	16.9	242.81	8	0.925
10-Oct-00	7:00 PM	13.4	14.4	14.5	16.3	243.8	7.2	0.925
10-Oct-00	7:30 PM	0	7.7	14.5	16.3	244.21	6.4	0.926
10-Oct-00	8:00 PM	12	11.2	9.5	15.7	244.93	5.8	0.926
10-Oct-00	8:30 PM	11.4	12	9.5	15.7	245.71	5.6	0.926
10-Oct-00	9:00 PM	1.2	6.8	9.4	15	246.04	5.5	0.927
10-Oct-00	9:30 PM	12.1	12.3	9.4	15	246.85	4.5	0.927
10-Oct-00	10:00 PM	12	12	12.2	14.5	247.65	3.5	0.928
10-Oct-00	10:30 PM	10.9	6.9	12.2	14.5	247.98	2.9	0.928
10-Oct-00	11:00 PM	12.5	12.2	9.5	13.9	248.78	3.3	0.928
10-Oct-00	11:30 PM	7.1	5.4	9.5	13.9	248.99	3.8	0.929
11-Oct-00	12:00 AM	10.7	10.5	8	13.3	249.65	3.4	0.929
11-Oct-00	12:30 AM	0	4.6	8	13.3	249.78	4	0.929
11-Oct-00	1:00 AM	8.9	9.3	6.9	12.8	250.33	4.5	0.929
11-Oct-00	1:30 AM	23.3	13.4	6.9	12.8	251.24	4.8	0.929
11-Oct-00	2:00 AM	9.2	0	6	12.4	250.86	5.1	0.93
11-Oct-00	2:30 AM	8.9	8.5	6	12.4	251.34	4.9	0.93
11-Oct-00	3:00 AM	0	2.4	5.5	12.1	251.28	4.6	0.93
11-Oct-00	3:30 AM	6.8	6.5	5.5	12.1	251.6	4.3	0.93
11-Oct-00	4:00 AM	9.7	8.1	7.3	11.9	252.05	3.8	0.93

228

11-Oct-00	4:30 AM	6.6	0.7	7.3	11.9	251.83	3	0.93
11-Oct-00	5:00 AM	8.2	7.5	4.1	11.7	252.22	1.1	0.93
11-Oct-00	5:30 AM	5	1.6	4.1	11.7	252.1	0.3	0.93
11-Oct-00	6:00 AM	9.5	8.4	5	11.4	252.58	-0.3	0.93
11-Oct-00	6:30 AM	9.6	4.7	5	11.4	252.72	1.3	0.93
11-Oct-00	7:00 AM	24	14.3	9.5	11.4	253.7	1.8	0.931
11-Oct-00	7:30 AM	9.3	0	9.5	11.4	253.35	2.2	0.93
11-Oct-00	8:00 AM	11.5	10.7	4.8	11	254.03	2.4	0.93
11-Oct-00	8:30 AM	10.4	4.4	4.8	11	254.15	2.8	0.93
11-Oct-00	9:00 AM	14	13.9	9.2	10.8	255.11	3.3	0.931
11-Oct-00	9:30 AM	2.5	5.1	9.2	10.8	255.28	3.9	0.931
11-Oct-00	10:00 AM	9.6	9.1	7.1	10.6	255.81	4.1	0.931
11-Oct-00	10:30 AM	3.8	11.3	7.1	10.6	256.51	4.4	0.931
11-Oct-00	11:00 AM	8.9	2.1	6.7	10.3	256.45	5	0.931
11-Oct-00	11:30 AM	9.1	10.2	6.7	10.3	257.07	4.9	0.931
11-Oct-00	12:00 PM	0	6.1	4.7	10	256.73	6.1	0.93
11-Oct-00	12:30 PM	7.4	7.1	4.7	10	257.1	6.4	0.929
11-Oct-00	1:00 PM	7.1	10	8.6	9.9	257.71	6.5	0.929
11-Oct-00	1:30 PM	6.2	6.5	8.6	9.9	258.02	6.4	0.929
11-Oct-00	2:00 PM	0	1.6	4.1	9.5	257.9	6.7	0.929
11-Oct-00	2:30 PM	12.2	11.2	4.1	9.5	258.62	7.6	0.93
11-Oct-00	3:00 PM	12.6	12.6	11.9	9.3	259.46	7.8	0.93
11-Oct-00	3:30 PM	12.4	12	11.9	9.3	260.24	8	0.93
11-Oct-00	4:00 PM	10.6	12.3	12.1	9	261.05	12	0.929
11-Oct-00	4:30 PM	15	13.1	12.1	9	261.94	11.6	0.929
11-Oct-00	5:00 PM	21.5	19.3	16.2	8.8	263.37	8.8	0.929
11-Oct-00	5:30 PM	1.9	13.3	16.2	8.8	264.26	4.6	0.928
11-Oct-00	6:00 PM	23	23.7	18.5	8.8	266.07	3.6	0.929
11-Oct-00	6:30 PM	21.7	21.8	18.5	8.8	267.71	2.9	0.929
11-Oct-00	7:00 PM	29	22.5	22.1	9.1	269.42	1.9	0.929
11-Oct-00	7:30 PM	26.4	27	22.1	9.1	271.52	1.4	0.929
11-Oct-00	8:00 PM	26.1	19.9	23.5	9.7	272.99	1.2	0.928
11-Oct-00	8:30 PM	37.9	38.3	23.5	9.7	276.06	0.4	0.928
11-Oct-00	9:00 PM	34.5	28.5	33.4	10.7	278.31	0	0.928
11-Oct-00	9:30 PM	31	30.7	33.4	10.7	280.74	-0.2	0.928
11-Oct-00	10:00 PM	29.2	36.6	33.6	11.6	283.67	-0.3	0.928
11-Oct-00	10:30 PM	22.9	17.6	33.6	11.6	284.94	-1	0.928
11-Oct-00	11:00 PM	28.6	26.9	22.2	12.1	287.01	-1.6	0.928
11-Oct-00	11:30 PM	27.5	18	22.2	12.1	288.34	-2.1	0.928
12-Oct-00	12:00 AM	17.1	17.8	17.9	12.5	289.62	-2.5	0.928
12-Oct-00	12:30 AM	36.9	30.7	17.9	12.5	292.07	-2.5	0.927
12-Oct-00	1:00 AM	18.9	10.5	20.6	13.1	292.7	-2.6	0.927
12-Oct-00	1:30 AM	9.9	11.4	20.6	13.1	293.43	-3.6	0.927
12-Oct-00	2:00 AM	31	22.6	17	13.6	295.13	-3.8	0.928
12-Oct-00	2:30 AM	20.6	9.6	17	13.6	295.71	-3.7	0.928
12-Oct-00	3:00 AM	8.3	13	11.3	13.8	296.58	-3.4	0.928
12-Oct-00	3:30 AM	13.1	20.4	11.3	13.8	298.08	-3.5	0.927
12-Oct-00	4:00 AM	19.2	10.1	15.3	14.1	298.73	-3.7	0.927
12-Oct-00	4:30 AM	14.4	11.4	15.3	14.1	299.47	-4.5	0.927
12-Oct-00	5:00 AM	1.6	13.2	12.3	14.5	300.35	-4.4	0.927
12-Oct-00	5:30 AM	35.8	22.6	12.3	14.5	302.1	-3.7	0.927
12-Oct-00	6:00 AM	21.9	10.8	16.7	15	302.76	-4.7	0.927
12-Oct-00	6:30 AM	14.9	14	16.7	15	303.72	-5.1	0.927
12-Oct-00	7:00 AM	2.8	19.3	16.7	15.3	305.13	-5	0.927
12-Oct-00	7:30 AM	27	20.8	16.7	15.3	306.71	-4.8	0.927
12-Oct-00	8:00 AM	27.4	20	20.4	15.9	308.2	-5.3	0.927
12-Oct-00	8:30 AM	17.4	20.2	20.4	15.9	309.69	-3.6	0.928
12-Oct-00	9:00 AM	21.6	27.8	24	16.5	311.84	-1.6	0.927
12-Oct-00	9:30 AM	22.8	16.7	24	16.5	313.06	0.2	0.928
12-Oct-00	10:00 AM	27.2	24.3	20.5	17.1	314.92	3.2	0.928
12-Oct-00	10:30 AM	15.6	18.2	20.5	17.1	316.25	6.8	0.929
12-Oct-00	11:00 AM	15.6	15.5	16.8	17.5	317.34	9.4	0.929

229

12-Oct-00	11:30 AM	16.8	16.4	16.8	17.5	318.51	10.7	0.929
12-Oct-00	12:00 PM	20.8	21.2	18.8	18.1	320.1	12.9	0.929
12-Oct-00	12:30 PM	27.6	27.4	18.8	18.1	322.24	16.7	0.928
12-Oct-00	1:00 PM	19	19.8	23.6	18.7	323.7	19.7	0.929
12-Oct-00	1:30 PM	17.4	17.7	23.6	18.7	324.99	19.9	0.929
12-Oct-00	2:00 PM	16	16.6	17.1	19.3	326.17	19.6	0.929
12-Oct-00	2:30 PM	27.1	25.4	17.1	19.3	328.13	16.4	0.929
12-Oct-00	3:00 PM	22.8	26.8	26.1	19.9	330.21	16.4	0.929
12-Oct-00	3:30 PM	18.3	19.1	26.1	19.9	331.61	16.2	0.929
12-Oct-00	4:00 PM	21.3	20	19.5	20.2	333.1	14.8	0.929
12-Oct-00	4:30 PM	18	18.6	19.5	20.2	334.47	19.7	0.929
12-Oct-00	5:00 PM	21.9	20.6	19.6	20.3	336	15.1	0.929
12-Oct-00	5:30 PM	30.2	27.8	19.6	20.3	338.18	10.5	0.929
12-Oct-00	6:00 PM	41.9	40.5	34.2	21	341.46	9.6	0.929
12-Oct-00	6:30 PM	38.2	39.5	34.2	21	344.65	9.2	0.929
12-Oct-00	7:00 PM	29.3	36	37.7	21.6	347.52	8.8	0.929
12-Oct-00	7:30 PM	32	32.1	37.7	21.6	350.07	7.7	0.929
12-Oct-00	8:00 PM	28.1	30.3	31.2	21.9	352.45	8	0.929
12-Oct-00	8:30 PM	38.7	32.4	31.2	21.9	355.03	7	0.928
12-Oct-00	9:00 PM	9.5	32.5	32.5	21.9	357.58	6.3	0.928
12-Oct-00	9:30 PM	39.6	30.3	32.5	21.9	360	5.5	0.928
12-Oct-00	10:00 PM	33.6	36.1	33.2	21.9	362.88	5.2	0.928
12-Oct-00	10:30 PM	29.6	32	33.2	21.9	365.41	5.4	0.928
12-Oct-00	11:00 PM	32.7	25.4	28.7	22.2	367.37	5.2	0.928
12-Oct-00	11:30 PM	33.9	33.6	28.7	22.2	370.04	5.1	0.928
13-Oct-00	12:00 AM	34.6	35.9	34.7	22.9	372.91	4.2	0.928
13-Oct-00	12:30 AM	25.1	24.9	34.7	22.9	374.82	3.9	0.928
13-Oct-00	1:00 AM	29.9	31.3	28.1	23.2	377.29	2.9	0.928
13-Oct-00	1:30 AM	37.1	32.1	28.1	23.2	379.82	2.8	0.928
13-Oct-00	2:00 AM	30.5	19.6	25.8	23.5	381.28	1.8	0.928
13-Oct-00	2:30 AM	31.9	32.4	25.8	23.5	383.86	1	0.928
13-Oct-00	3:00 AM	34.1	26.8	29.6	24.3	385.93	1.4	0.928
13-Oct-00	3:30 AM	43.5	37.6	29.6	24.3	388.98	-0.3	0.927
13-Oct-00	4:00 AM	33.1	23.5	30.6	24.9	390.75	-0.8	0.927
13-Oct-00	4:30 AM	31.7	33.5	30.6	24.9	393.39	-1.3	0.927
13-Oct-00	5:00 AM	30.1	20.1	26.8	25.5	394.91	-1.5	0.927
13-Oct-00	5:30 AM	9.2	27.1	26.8	25.5	396.99	-2	0.927
13-Oct-00	6:00 AM	28.5	23.4	25.2	25.9	398.79	-2	0.927
13-Oct-00	6:30 AM	17.1	23.2	25.2	25.9	400.56	-2.5	0.927
13-Oct-00	7:00 AM	45.2	35.6	29.4	26.4	403.41	-2.9	0.927
13-Oct-00	7:30 AM	32.2	21.8	29.4	26.4	405.05	-1.8	0.927
13-Oct-00	8:00 AM	13.1	21.1	21.4	26.5	406.63	-1.4	0.927
13-Oct-00	8:30 AM	41.4	36	21.4	26.5	409.52	-0.5	0.927
13-Oct-00	9:00 AM	25.6	22.9	29.5	26.7	411.26	-0.2	0.928
13-Oct-00	9:30 AM	38.1	33.2	29.5	26.7	413.87	1.1	0.928
13-Oct-00	10:00 AM	32.2	19.7	26.4	26.9	415.35	3.3	0.928
13-Oct-00	10:30 AM	32.1	35	26.4	26.9	418.14	8.2	0.928
13-Oct-00	11:00 AM	21.1	22.4	28.7	27.4	419.83	11.4	0.929
13-Oct-00	11:30 AM	22	20.2	28.7	27.4	421.33	10.4	0.929
13-Oct-00	12:00 PM	21.6	22.2	21.2	27.5	423.01	11	0.929
13-Oct-00	12:30 PM	17.1	18	21.2	27.5	424.31	11	0.929
13-Oct-00	1:00 PM	14.1	16.7	17.3	27.3	425.51	11.8	0.929
13-Oct-00	1:30 PM	13.8	14.6	17.3	27.3	426.52	12	0.929
13-Oct-00	2:00 PM	18.8	16.7	15.6	27.2	427.72	12.2	0.928
13-Oct-00	2:30 PM	21.1	21.7	15.6	27.2	429.36	10.2	0.928
13-Oct-00	3:00 PM	21.5	21.9	21.8	27	431.01	10.3	0.928
13-Oct-00	3:30 PM	68.4	38.6	21.8	27	434.16	11.5	0.928
13-Oct-00	4:00 PM	22.7	52	45.3	28.1	438.4	16	0.928
13-Oct-00	4:30 PM	19.5	19.3	45.3	28.1	439.83	16.5	0.928
13-Oct-00	5:00 PM	22.5	22.2	20.7	28.2	441.5	11.5	0.927
13-Oct-00	5:30 PM	20.4	22.3	20.7	28.2	443.19	9.8	0.928
13-Oct-00	6:00 PM	24	22.8	22.5	27.7	444.93	8.9	0.928

13-Oct-00	6:30 PM	41.3	49.4	22.5	27.7	448.98	7.5	0.928
13-Oct-00	7:00 PM	20.6	27.2	38.3	27.7	451.09	6.5	0.928
13-Oct-00	7:30 PM	26.2	25.7	38.3	27.7	453.08	5.7	0.927
13-Oct-00	8:00 PM	26	28.7	27.2	27.5	455.32	5	0.927
13-Oct-00	8:30 PM	25.6	19	27.2	27.5	456.72	4.4	0.927
13-Oct-00	9:00 PM	33	32.2	25.6	27.2	459.28	4.1	0.927
13-Oct-00	9:30 PM	23.1	25.5	25.6	27.2	461.25	4.6	0.927
13-Oct-00	10:00 PM	42.4	36.3	30.9	27.1	464.16	4.8	0.927
13-Oct-00	10:30 PM	14.6	35.1	30.9	27.1	466.95	4.7	0.927
13-Oct-00	11:00 PM	28.9	29.9	32.5	27.3	469.31	4.5	0.927
13-Oct-00	11:30 PM	37.5	33.1	32.5	27.3	471.93	4.2	0.927
14-Oct-00	12:00 AM	36.6	24.5	28.8	27.1	473.83	3.4	0.927
14-Oct-00	12:30 AM	37.9	36.3	28.8	27.1	476.71	3.3	0.927
14-Oct-00	1:00 AM	33.3	22.3	29.3	27.1	478.43	3.4	0.927
14-Oct-00	1:30 AM	45.2	38	29.3	27.1	481.48	3.3	0.927
14-Oct-00	2:00 AM	28.9	19.3	28.7	27.2	482.91	3	0.927
14-Oct-00	2:30 AM	42.4	33.8	28.7	27.2	485.59	2.4	0.927
14-Oct-00	3:00 AM	26.5	16.4	25.1	27	486.77	1.7	0.926
14-Oct-00	3:30 AM	23.8	28.7	25.1	27	488.99	1.9	0.926
14-Oct-00	4:00 AM	27.9	17.6	23.2	26.7	490.29	2.3	0.926
14-Oct-00	4:30 AM	5.9	23.4	23.2	26.7	492.07	2.1	0.926
14-Oct-00	5:00 AM	28.9	25.1	24.3	26.6	494.01	1.5	0.926
14-Oct-00	5:30 AM	15.1	21	24.3	26.6	495.58	0.9	0.926
14-Oct-00	6:00 AM	28.8	29.5	25.2	26.6	497.89	0.8	0.926
14-Oct-00	6:30 AM	22.4	19.7	25.2	26.6	499.35	1.2	0.926
14-Oct-00	7:00 AM	43.2	31.7	25.7	26.5	501.88	1.2	0.926
14-Oct-00	7:30 AM	26.4	18.8	25.7	26.5	503.23	1.6	0.926
14-Oct-00	8:00 AM	3.4	23.6	21.2	26.5	505.02	2.1	0.926
14-Oct-00	8:30 AM	30.7	25.3	21.2	26.5	506.99	2.3	0.926
14-Oct-00	9:00 AM	3.5	24.2	24.7	26.3	508.82	2.8	0.927
14-Oct-00	9:30 AM	28.6	27.5	24.7	26.3	510.97	3.8	0.927
14-Oct-00	10:00 AM	26.2	29	28.2	26.3	513.24	5.4	0.927
14-Oct-00	10:30 AM	68.9	54.2	28.2	26.3	517.72	6.1	0.927
14-Oct-00	11:00 AM	27.4	28	41.1	26.9	519.9	6.8	0.927
14-Oct-00	11:30 AM	27.6	28.4	41.1	26.9	522.13	6.7	0.927
14-Oct-00	12:00 PM	38.5	28.5	28.5	27.2	524.38	4.9	0.927
14-Oct-00	12:30 PM	17.5	7.6	28.5	27.2	524.76	5.4	0.926
14-Oct-00	1:00 PM	19.5	22.4	15	27.1	526.45	5.6	0.926
14-Oct-00	1:30 PM	1.4	10	15	27.1	527.05	5.5	0.926
14-Oct-00	2:00 PM	15.5	16.7	13.3	27	528.25	5.6	0.926
14-Oct-00	2:30 PM	13.8	14	13.3	27	529.22	5.3	0.927
14-Oct-00	3:00 PM	10.3	4.7	9.4	26.5	529.37	5.7	0.927
14-Oct-00	3:30 PM	12.1	12.7	9.4	26.5	530.22	6	0.927
14-Oct-00	4:00 PM	10.5	12.5	12.6	25.1	531.04	5.8	0.927
14-Oct-00	4:30 PM	3.3	1.4	12.6	25.1	530.9	6	0.927
14-Oct-00	5:00 PM	14.7	13.6	7.5	24.5	531.83	5.9	0.927
14-Oct-00	5:30 PM	12.1	16.7	7.5	24.5	533.02	5.6	0.927
14-Oct-00	6:00 PM	0	12	14.3	24.2	533.77	4.7	0.927
14-Oct-00	6:30 PM	10.4	2.9	14.3	24.2	533.8	4.9	0.928
14-Oct-00	7:00 PM	8.4	9.7	6.3	22.9	534.38	3.5	0.928
14-Oct-00	7:30 PM	0	2	6.3	22.9	534.28	2.2	0.928
14-Oct-00	8:00 PM	9.1	8.2	5.1	21.9	534.74	1.5	0.927
14-Oct-00	8:30 PM	8.1	8.5	5.1	21.9	535.23	1.1	0.927
14-Oct-00	9:00 PM	10.1	0.7	4.6	21.1	535.02	0.2	0.927
14-Oct-00	9:30 PM	9.9	9.8	4.6	21.1	535.61	-0.5	0.927
14-Oct-00	10:00 PM	11.9	1.7	5.7	20	535.5	-0.9	0.927
14-Oct-00	10:30 PM	20.5	13.6	5.7	20	536.46	-1.4	0.927
14-Oct-00	11:00 PM	13.4	3.3	8.5	19	536.45	-1.2	0.927
14-Oct-00	11:30 PM	0	9.2	8.5	19	536.97	-1.1	0.927
15-Oct-00	12:00 AM	10.4	5	7.1	18.1	537.16	-1.5	0.927
15-Oct-00	12:30 AM	0	1.8	7.1	18.1	537.06	-2.6	0.927
15-Oct-00	1:00 AM	10.4	10.9	6.3	17.1	537.75	-2.9	0.927

15-Oct-00	1:30 AM	8.6	1.4	6.3	17.1	537.61	-3.3	0.927
15-Oct-00	2:00 AM	0	7.7	4.6	16.1	537.99	-2.8	0.926
15-Oct-00	2:30 AM	9.8	4.7	4.6	16.1	538.17	-3.7	0.927
15-Oct-00	3:00 AM	1.4	2.9	3.8	15.3	538.16	-4	0.927
15-Oct-00	3:30 AM	24.3	15.1	3.8	15.3	539.21	-2.8	0.927
15-Oct-00	4:00 AM	10.2	0	7.1	14.6	538.87	-2.7	0.926
15-Oct-00	4:30 AM	1.8	1.8	7.1	14.6	538.77	-3.4	0.927
15-Oct-00	5:00 AM	22.9	13.9	7.9	13.9	539.71	-3.3	0.927
15-Oct-00	5:30 AM	7.2	0	7.9	13.9	539.22	-4.1	0.927
15-Oct-00	6:00 AM	0	1.6	0	12.8	539.1	-4.3	0.926
15-Oct-00	6:30 AM	18.7	10.6	0	12.8	539.79	-4.6	0.926
15-Oct-00	7:00 AM	8.4	0.9	5.8	12	539.58	-4.9	0.926
15-Oct-00	7:30 AM	3.5	4.8	5.8	12	539.74	-4.6	0.926
15-Oct-00	8:00 AM	0	11.8	8.3	11.5	540.49	-5.2	0.926
15-Oct-00	8:30 AM	20.6	10	8.3	11.5	541.13	-3.6	0.926
15-Oct-00	9:00 AM	14.7	10.9	10.4	10.9	541.82	-1.1	0.926
15-Oct-00	9:30 AM	16.6	15.8	10.4	10.9	542.94	0.8	0.926
15-Oct-00	10:00 AM	11.4	9.3	12.5	10.2	543.48	3.1	0.926
15-Oct-00	10:30 AM	9	6.6	12.5	10.2	543.8	5.1	0.926
15-Oct-00	11:00 AM	0	4.3	5.5	8.7	543.91	8	0.926
15-Oct-00	11:30 AM	5.1	3.5	5.5	8.7	543.96	8.1	0.926
15-Oct-00	12:00 PM	6.1	7.9	5.7	7.8	544.38	8.8	0.926
15-Oct-00	12:30 PM	2.6	4.2	5.7	7.8	544.48	10.7	0.926
15-Oct-00	1:00 PM	0.5	2	3.1	7.3	544.39	12.2	0.925
15-Oct-00	1:30 PM	3.4	2.8	3.1	7.3	544.37	13.3	0.925
15-Oct-00	2:00 PM	4.2	3.4	3.1	6.9	544.41	12	0.925
15-Oct-00	2:30 PM	6.9	7.9	3.1	6.9	544.84	10.6	0.924
15-Oct-00	3:00 PM	6	6.4	7.1	6.8	545.14	10.8	0.923
15-Oct-00	3:30 PM	5	6.6	7.1	6.8	545.45	10.5	0.923
15-Oct-00	4:00 PM	2.8	5.3	5.9	6.5	545.65	14.6	0.923
15-Oct-00	4:30 PM	4.8	4.7	5.9	6.5	545.8	14.7	0.922
15-Oct-00	5:00 PM	8.2	7.7	6.2	6.4	546.22	10.2	0.922
15-Oct-00	5:30 PM	10.5	8.9	6.2	6.4	546.74	9.2	0.922
15-Oct-00	6:00 PM	10.4	11.4	10.1	6.3	547.46	7.7	0.921
15-Oct-00	6:30 PM	0	8	10.1	6.3	547.9	5.9	0.921
15-Oct-00	7:00 PM	15.7	15.7	11.8	6.5	549.01	4.8	0.921
15-Oct-00	7:30 PM	12.8	14.1	11.8	6.5	549.98	4.7	0.921
15-Oct-00	8:00 PM	8.1	5.7	9.9	6.7	550.22	4.8	0.92
15-Oct-00	8:30 PM	14.9	17.2	9.9	6.7	551.46	4.2	0.92
15-Oct-00	9:00 PM	0	12	14.6	7.1	552.22	4.5	0.92
15-Oct-00	9:30 PM	15.5	9.9	14.6	7.1	552.85	4.5	0.92
15-Oct-00	10:00 PM	24.9	16.4	13.2	7.4	554.05	4.1	0.919
15-Oct-00	10:30 PM	17.6	7	13.2	7.4	554.37	3.6	0.919
15-Oct-00	11:00 PM	15.8	16.9	11.9	7.6	555.58	4	0.919
15-Oct-00	11:30 PM	15.7	6.5	11.9	7.6	555.89	3.6	0.919
16-Oct-00	12:00 AM	13.5	15.8	11.2	7.7	557.01	4	0.919
16-Oct-00	12:30 AM	0	7.5	11.2	7.7	557.39	3.8	0.92
16-Oct-00	1:00 AM	16.6	14.6	11	7.9	558.42	3.6	0.92
16-Oct-00	1:30 AM	14.6	15.4	11	7.9	559.5	2.1	0.92
16-Oct-00	2:00 AM	9.2	4.1	9.8	8.1	559.6	-0.1	0.92
16-Oct-00	2:30 AM	15.1	18.6	9.8	8.1	560.96	1.9	0.921
16-Oct-00	3:00 AM	0	2.7	10.6	8.4	560.93	1.8	0.921
16-Oct-00	3:30 AM	9.9	13	10.6	8.4	561.81	0	0.92
16-Oct-00	4:00 AM	0	0	5.9	8.4	561.44	1.2	0.92
16-Oct-00	4:30 AM	9	11.1	5.9	8.4	562.14	1.6	0.921
16-Oct-00	5:00 AM	7.1	0.7	5.9	8.3	561.95	0.7	0.921
16-Oct-00	5:30 AM	9.8	11.2	5.9	8.3	562.66	0.8	0.921
16-Oct-00	6:00 AM	9	0	5.4	8.5	562.37	-0.6	0.921
16-Oct-00	6:30 AM	0	9.8	5.4	8.5	562.94	-0.7	0.921
16-Oct-00	7:00 AM	11.3	3.9	6.8	8.6	563.04	-0.9	0.921
16-Oct-00	7:30 AM	0	1.3	6.8	8.6	562.89	-0.9	0.921
16-Oct-00	8:00 AM	13.7	15.3	8.3	8.6	563.98	-1.4	0.921

16-Oct-00	8:30 AM	22.2	6.3	8.3	8.6	564.28	-0.6	0.921
16-Oct-00	9:00 AM	18.1	23.8	15.1	8.8	566.09	-1.1	0.921
16-Oct-00	9:30 AM	24.2	10.3	15.1	8.8	566.73	1.2	0.921
16-Oct-00	10:00 AM	17.2	19.1	14.7	8.9	568.13	5.3	0.921
16-Oct-00	10:30 AM	14	12.7	14.7	8.9	568.99	10	0.922
16-Oct-00	11:00 AM	10	11.6	12.1	9.2	569.73	12	0.922
16-Oct-00	11:30 AM	0.8	4	12.1	9.2	569.81	11.7	0.922
16-Oct-00	12:00 PM	12.5	11.6	7.8	9.2	570.56	12.9	0.922
16-Oct-00	12:30 PM	6.5	9.3	7.8	9.2	571.1	14.5	0.922
16-Oct-00	1:00 PM	13.6	8.1	8.7	9.5	571.55	14.8	0.923
16-Oct-00	1:30 PM	4.5	4.7	8.7	9.5	571.7	14.5	0.922
16-Oct-00	2:00 PM	4.1	5.4	5.1	9.6	571.91	14.4	0.923
16-Oct-00	2:30 PM	8.2	8	5.1	9.6	572.35	13.7	0.923
16-Oct-00	3:00 PM	102	50.5	29.3	10.5	576.53	13.7	0.922
16-Oct-00	3:30 PM	37.4	88.4	29.3	10.5	583.98	14.7	0.923
16-Oct-00	4:00 PM	5.6	9.4	48.9	12.3	584.52	18.2	0.923
16-Oct-00	4:30 PM	3.7	5.3	48.9	12.3	584.73	17.1	0.923
16-Oct-00	5:00 PM	11.5	10	7.7	12.3	585.35	10.7	0.923
16-Oct-00	5:30 PM	15.1	13.6	7.7	12.3	586.28	9.2	0.923
16-Oct-00	6:00 PM	9.1	12	12.8	12.4	587.06	8.4	0.923
16-Oct-00	6:30 PM	9.6	10	12.8	12.4	587.67	6.9	0.923
16-Oct-00	7:00 PM	11.3	9.9	10	12.4	588.29	5.8	0.923
16-Oct-00	7:30 PM	12.4	0	10	12.4	588.01	5.1	0.923
16-Oct-00	8:00 PM	12.1	13.6	6.7	12.2	588.94	4.5	0.923
16-Oct-00	8:30 PM	11.9	11.3	6.7	12.2	589.66	3.1	0.923
16-Oct-00	9:00 PM	12.5	1	6.1	11.9	589.49	2.5	0.924
16-Oct-00	9:30 PM	11.6	14.9	6.1	11.9	590.53	2.7	0.924
16-Oct-00	10:00 PM	0	2	8.5	11.7	590.43	0.1	0.924
16-Oct-00	10:30 PM	20.3	16.2	8.5	11.7	591.6	-0.5	0.924
16-Oct-00	11:00 PM	0	6.7	11.4	11.7	591.91	-0.6	0.924
16-Oct-00	11:30 PM	18	17.6	11.4	11.7	593.19	-0.5	0.924
17-Oct-00	12:00 AM	1.7	6.4	12	11.7	593.49	-0.8	0.925
17-Oct-00	12:30 AM	20.3	21.5	12	11.7	595.11	-1.6	0.925
17-Oct-00	1:00 AM	18.7	11	16.2	11.9	595.81	-1.9	0.925
17-Oct-00	1:30 AM	27.4	24.5	16.2	11.9	597.67	-2.9	0.925
17-Oct-00	2:00 AM	20.3	5	14.7	12.1	597.86	-3.7	0.925
17-Oct-00	2:30 AM	0	6.9	14.7	12.1	598.19	-4	0.925
17-Oct-00	3:00 AM	14.9	17.9	12.4	12.2	599.49	-3.8	0.926
17-Oct-00	3:30 AM	19.3	7.3	12.4	12.2	599.87	-3.8	0.926
17-Oct-00	4:00 AM	0	6.4	6.9	12.2	600.15	-3.9	0.926
17-Oct-00	4:30 AM	16.7	16.9	6.9	12.2	601.38	-3.9	0.926
17-Oct-00	5:00 AM	16.1	7.2	12	12.5	601.75	-3.6	0.926
17-Oct-00	5:30 AM	0	7	12	12.5	602.08	-3.3	0.926
17-Oct-00	6:00 AM	16.7	17.5	12.2	12.8	603.36	-3.4	0.926
17-Oct-00	6:30 AM	18.2	6.3	12.2	12.8	603.65	-3.2	0.926
17-Oct-00	7:00 AM	0	13.7	10	12.9	604.56	-3	0.926
17-Oct-00	7:30 AM	22.5	17.8	10	12.9	605.88	-3.4	0.926
17-Oct-00	8:00 AM	18.9	12.3	15.1	13.2	606.7	-3.3	0.926
17-Oct-00	8:30 AM	7.3	23.2	15.1	13.2	608.43	-3	0.926
17-Oct-00	9:00 AM	20	15.7	19.4	13.4	609.57	-0.3	0.927
17-Oct-00	9:30 AM	0.7	5.6	19.4	13.4	609.78	0.7	0.927
17-Oct-00	10:00 AM	20.1	19.3	12.4	13.3	611.21	1.6	0.926
17-Oct-00	10:30 AM	13.8	6.2	12.4	13.3	611.49	2.9	0.926
17-Oct-00	11:00 AM	17.5	17.9	12.1	13.3	612.8	5.4	0.926
17-Oct-00	11:30 AM	0	5.3	12.1	13.3	612.98	7.4	0.926
17-Oct-00	12:00 PM	10	10.4	7.9	13.3	613.64	10.3	0.926
17-Oct-00	12:30 PM	11	10.1	7.9	13.3	614.26	11	0.926
17-Oct-00	1:00 PM	7.9	9.1	9.6	13.3	614.8	10.8	0.925
17-Oct-00	1:30 PM	7.2	9.1	9.6	13.3	615.34	10.6	0.925
17-Oct-00	2:00 PM	10.5	11	10.1	13.5	616.03	11.5	0.925
17-Oct-00	2:30 PM	9.5	13.4	10.1	13.5	616.94	12.2	0.925
17-Oct-00	3:00 PM	13.2	11.6	12.5	12.8	617.7	12.2	0.924

17-Oct-00	3:30 PM	13.2	14.6	12.5	12.8	618.71	11.8	0.924
17-Oct-00	4:00 PM	20.2	16.7	15.6	11.4	619.91	11.8	0.924
17-Oct-00	4:30 PM	15.9	15.7	15.6	11.4	621.02	14.6	0.923
17-Oct-00	5:00 PM	20.6	18.7	17.2	11.8	622.4	10.5	0.923
17-Oct-00	5:30 PM	22.4	23.8	17.2	11.8	624.21	9.7	0.922
17-Oct-00	6:00 PM	27.7	24.8	24.3	12.3	626.12	8.8	0.922
17-Oct-00	6:30 PM	3.9	24	24.3	12.3	627.95	8	0.922
17-Oct-00	7:00 PM	29	27.8	25.9	13	630.12	7.1	0.921
17-Oct-00	7:30 PM	25.3	28	25.9	13	632.31	6.4	0.921
17-Oct-00	8:00 PM	4.8	21.5	24.8	13.7	633.89	6.5	0.92
17-Oct-00	8:30 PM	30.6	19.7	24.8	13.7	635.39	6.5	0.92
17-Oct-00	9:00 PM	28.9	31.9	25.8	14.5	637.91	6	0.919
17-Oct-00	9:30 PM	11.1	15.4	25.8	14.5	638.99	5.7	0.919
17-Oct-00	10:00 PM	26.9	28	21.7	15.1	641.18	6.7	0.918
17-Oct-00	10:30 PM	20.1	23	21.7	15.1	642.92	8.1	0.918
17-Oct-00	11:00 PM	22.5	14.2	18.6	15.4	643.91	7.8	0.917
17-Oct-00	11:30 PM	25.4	28.1	18.6	15.4	646.09	7.3	0.917
18-Oct-00	12:00 AM	21.2	23.2	25.6	16	647.86	6.7	0.916
18-Oct-00	12:30 AM	19.8	11.4	25.6	16	648.59	6.2	0.916
18-Oct-00	1:00 AM	23.1	25.5	18.4	16.1	650.55	5.6	0.916
18-Oct-00	1:30 AM	17.5	22.5	18.4	16.1	652.23	5.3	0.916
18-Oct-00	2:00 AM	23.8	13.1	17.8	16.2	653.14	4.9	0.916
18-Oct-00	2:30 AM	19.8	22	17.8	16.2	654.81	4.1	0.915
18-Oct-00	3:00 AM	17.5	10.4	16.2	16.3	655.45	3.5	0.915
18-Oct-00	3:30 AM	22.1	23.3	16.2	16.3	657.23	3.2	0.915
18-Oct-00	4:00 AM	0	10.9	17.1	16.8	657.91	2.1	0.915
18-Oct-00	4:30 AM	21	20.1	17.1	16.8	659.41	1.8	0.914
18-Oct-00	5:00 AM	31.4	22.3	21.2	17.1	661.12	1.7	0.914
18-Oct-00	5:30 AM	19.5	7.4	21.2	17.1	661.48	1.5	0.914
18-Oct-00	6:00 AM	17.5	20.5	14	17.2	663.01	1.5	0.914
18-Oct-00	6:30 AM	9.9	3.5	14	17.2	663.05	2.6	0.913
18-Oct-00	7:00 AM	21.1	21.7	12.6	17.3	664.69	2.2	0.914
18-Oct-00	7:30 AM	3.3	3.8	12.6	17.3	664.75	3.3	0.914
18-Oct-00	8:00 AM	16.8	17.8	10.8	17.2	666.05	2.2	0.914
18-Oct-00	8:30 AM	0	10	10.8	17.2	666.64	4.9	0.914
18-Oct-00	9:00 AM	20.4	13	11.5	16.8	667.54	5.1	0.914
18-Oct-00	9:30 AM	31.2	26.9	11.5	16.8	669.64	6.3	0.914
18-Oct-00	10:00 AM	24.9	26.8	26.9	17.4	671.72	7.4	0.914
18-Oct-00	10:30 AM	18.8	21.5	26.9	17.4	673.33	7	0.915
18-Oct-00	11:00 AM	17.2	17.1	19.3	17.7	674.55	10.7	0.915
18-Oct-00	11:30 AM	12.8	14.9	19.3	17.7	675.59	16	0.916
18-Oct-00	12:00 PM	14.8	14.1	14.5	18	676.56	14.5	0.916
18-Oct-00	12:30 PM	15.6	14.9	14.5	18	677.61	14.3	0.917
18-Oct-00	1:00 PM	13.7	12.7	13.8	18.2	678.46	15.5	0.917
18-Oct-00	1:30 PM	9.2	8.9	13.8	18.2	678.97	16	0.917
18-Oct-00	2:00 PM	8.4	7.6	8.2	18.1	679.37	12.4	0.918
18-Oct-00	2:30 PM	11.1	10.1	8.2	18.1	679.99	13.7	0.918
18-Oct-00	3:00 PM	6.5	8.7	9.4	18	680.49	13.2	0.918
18-Oct-00	3:30 PM	7	8	9.4	18	680.93	13.2	0.918
18-Oct-00	4:00 PM	6.9	10	9	17.7	681.55	17.3	0.918
18-Oct-00	4:30 PM	3.1	4.5	9	17.7	681.67	17.8	0.918
18-Oct-00	5:00 PM	6.2	5.8	5.1	17.2	681.91	12.8	0.918
18-Oct-00	5:30 PM	9.5	8.2	5.1	17.2	682.37	12.1	0.918
18-Oct-00	6:00 PM	19.3	20.3	14.3	16.8	683.89	9.3	0.918
18-Oct-00	6:30 PM	23.7	23.8	14.3	16.8	685.71	8.4	0.918
18-Oct-00	7:00 PM	10.5	12.6	18.2	16.5	686.54	8.9	0.918
18-Oct-00	7:30 PM	10.4	11.2	18.2	16.5	687.26	8.2	0.918
18-Oct-00	8:00 PM	0	0	5.2	15.6	686.92	7.5	0.919
18-Oct-00	8:30 PM	20.6	18.1	5.2	15.6	688.25	5.9	0.919
18-Oct-00	9:00 PM	15.6	20.1	19.1	15.4	689.74	6.1	0.919
18-Oct-00	9:30 PM	0	4.8	19.1	15.4	689.89	5.5	0.919
18-Oct-00	10:00 PM	16.2	16.2	10.5	14.9	691.05	4.9	0.92

234

18-Oct-00	10:30 PM	10.3	12.8	10.5	14.9	691.9	5.9	0.92
18-Oct-00	11:00 PM	10.5	0	5.5	14.3	691.49	5.9	0.92
18-Oct-00	11:30 PM	9.7	11.7	5.5	14.3	692.24	5.6	0.92
19-Oct-00	12:00 AM	0	0	4.8	13.5	691.78	4.3	0.92
19-Oct-00	12:30 AM	10.8	10.1	4.8	13.5	692.42	3.7	0.921
19-Oct-00	1:00 AM	20.5	11.6	10.8	13.2	693.18	3	0.921
19-Oct-00	1:30 AM	10.8	0	10.8	13.2	692.53	2.2	0.921
19-Oct-00	2:00 AM	7.6	10.1	2.9	12.5	693.15	-0.1	0.922
19-Oct-00	2:30 AM	11.4	0	2.9	12.5	692.79	-0.7	0.922
19-Oct-00	3:00 AM	9.4	11.5	5.2	12.1	693.53	-1.5	0.922
19-Oct-00	3:30 AM	12.5	0	5.2	12.1	693.13	-2.2	0.922
19-Oct-00	4:00 AM	0	3.2	0.8	11.4	693.12	-0.8	0.923
19-Oct-00	4:30 AM	13.9	9.1	0.8	11.4	693.68	-0.2	0.923
19-Oct-00	5:00 AM	0.3	0.5	4.8	10.7	693.45	-0.3	0.923
19-Oct-00	5:30 AM	23.1	15.4	4.8	10.7	694.56	0.5	0.923
19-Oct-00	6:00 AM	13.9	0.1	7.7	10.5	694.29	1.4	0.923
19-Oct-00	6:30 AM	0	4.1	7.7	10.5	694.37	0.7	0.924
19-Oct-00	7:00 AM	14.7	12.1	8.1	10.3	695.17	0.4	0.924
19-Oct-00	7:30 AM	3.2	1.5	8.1	10.3	695.04	-0.1	0.924
19-Oct-00	8:00 AM	21.9	18.6	10.1	10.2	696.43	-0.4	0.925
19-Oct-00	8:30 AM	16.7	4.4	10.1	10.2	696.53	-0.4	0.925
19-Oct-00	9:00 AM	5.7	8.7	6.5	10	697.03	0.8	0.925
19-Oct-00	9:30 AM	14.7	20.2	6.5	10	698.53	2.2	0.925
19-Oct-00	10:00 AM	0	0.5	10.4	9.3	698.31	4.8	0.926
19-Oct-00	10:30 AM	12.3	12.5	10.4	9.3	699.14	7.7	0.926
19-Oct-00	11:00 AM	15.2	14.3	13.4	9.1	700.13	10	0.926
19-Oct-00	11:30 AM	13.5	17	13.4	9.1	701.35	9.5	0.927
19-Oct-00	12:00 PM	12.7	13.4	15.2	9.1	702.26	8	0.927
19-Oct-00	12:30 PM	8.8	12.3	15.2	9.1	703.07	7.7	0.927
19-Oct-00	1:00 PM	7.2	7.7	10	9	703.48	10.9	0.927
19-Oct-00	1:30 PM	6.4	7.1	10	9	703.85	11.2	0.927
19-Oct-00	2:00 PM	6.5	4.4	5.8	8.9	703.96	11.3	0.927
19-Oct-00	2:30 PM	6.7	5.7	5.8	8.9	704.2	8.2	0.927
19-Oct-00	3:00 PM	8.5	9.5	7.6	8.8	704.77	7.9	0.927
19-Oct-00	3:30 PM	10.2	10.2	7.6	8.8	705.4	8.5	0.927
19-Oct-00	4:00 PM	0	2.9	6.5	8.7	705.37	12.9	0.927
19-Oct-00	4:30 PM	8.1	6.5	6.5	8.7	705.69	13.1	0.927
19-Oct-00	5:00 PM	28.9	22.3	14.4	9.1	707.39	6.8	0.928
19-Oct-00	5:30 PM	15	19	14.4	9.1	708.77	5.9	0.927
19-Oct-00	6:00 PM	0	9.9	14.4	9.1	709.33	4.3	0.927
19-Oct-00	6:30 PM	37.7	16.2	14.4	9.1	710.57	2.2	0.927
19-Oct-00	7:00 PM	20.5	30	23.1	9.3	712.89	1.5	0.927
19-Oct-00	7:30 PM	14.4	12.6	23.1	9.3	713.72	0.4	0.927
19-Oct-00	8:00 PM	34.4	33	22.8	10	716.36	-0.5	0.927
19-Oct-00	8:30 PM	23.9	20.7	22.8	10	717.9	-1.1	0.927
19-Oct-00	9:00 PM	33.7	33.5	27.1	10.3	720.56	0.1	0.927
19-Oct-00	9:30 PM	44.5	31	27.1	10.3	723.02	-0.7	0.927
19-Oct-00	10:00 PM	52.8	45.4	38.2	11.5	726.73	-2.1	0.926
19-Oct-00	10:30 PM	52	33.5	38.2	11.5	729.37	-1.9	0.926
19-Oct-00	11:00 PM	9	16.5	25	12.3	730.55	-2	0.926
19-Oct-00	11:30 PM	32.2	30.3	25	12.3	732.9	-1.6	0.925
20-Oct-00	12:00 AM	27	12.2	21.2	13	733.74	-1.1	0.925
20-Oct-00	12:30 AM	16.3	10.2	21.2	13	734.37	-1.7	0.924
20-Oct-00	1:00 AM	0	11.4	10.8	13	735.07	-1.4	0.924
20-Oct-00	1:30 AM	19.5	15.3	10.8	13	736.17	-1	0.923
20-Oct-00	2:00 AM	16.9	4.8	10	13.3	736.32	-1	0.923
20-Oct-00	2:30 AM	2.6	2.8	10	13.3	736.3	-0.7	0.922
20-Oct-00	3:00 AM	0	14.8	8.8	13.4	737.29	-0.5	0.922
20-Oct-00	3:30 AM	17.1	8.7	8.8	13.4	737.83	-0.4	0.921
20-Oct-00	4:00 AM	13.3	3	5.8	13.7	737.83	-0.8	0.92
20-Oct-00	4:30 AM	0	5.7	5.8	13.7	738.05	-0.5	0.919
20-Oct-00	5:00 AM	25.8	18.2	11.9	14	739.39	-0.9	0.92

235

20-Oct-00	5:30 AM	16.2	0	11.9	14	739.08	-0.7	0.919
20-Oct-00	6:00 AM	5.4	2.1	0.8	13.7	739	-0.5	0.918
20-Oct-00	6:30 AM	0	7.8	0.8	13.7	739.4	-0.6	0.917
20-Oct-00	7:00 AM	13.7	11.1	9.5	13.7	740.14	-1.1	0.916
20-Oct-00	7:30 AM	13.5	2.9	9.5	13.7	740.12	-1.3	0.916
20-Oct-00	8:00 AM	9.2	5.4	4.1	13.5	740.34	-1.1	0.915
20-Oct-00	8:30 AM	0	10.4	4.1	13.5	740.96	-0.6	0.916
20-Oct-00	9:00 AM	20.3	15.8	13.1	13.7	742.1	-0.4	0.915
20-Oct-00	9:30 AM	19	7.4	13.1	13.7	742.49	0.8	0.915
20-Oct-00	10:00 AM	0	8.3	7.9	13.6	742.94	1.4	0.914
20-Oct-00	10:30 AM	19.6	19.6	7.9	13.6	744.4	1.8	0.913
20-Oct-00	11:00 AM	18.4	8.2	13.9	13.7	744.86	2.4	0.913
20-Oct-00	11:30 AM	17.3	22.4	13.9	13.7	746.52	4.3	0.912
20-Oct-00	12:00 PM	19.2	13.5	17.9	13.8	747.47	4.5	0.912
20-Oct-00	12:30 PM	16.3	15.6	17.9	13.8	748.57	5.4	0.911
20-Oct-00	1:00 PM	19.4	22.4	19	14.2	750.26	5.8	0.911
20-Oct-00	1:30 PM	4.1	8.1	19	14.2	750.71	5.8	0.91
20-Oct-00	2:00 PM	28.7	26.9	17.5	14.6	752.8	6.1	0.91
20-Oct-00	2:30 PM	25.4	25.9	17.5	14.6	754.78	6.2	0.91
20-Oct-00	3:00 PM	26	12.5	19.2	15.1	755.63	6.6	0.909
20-Oct-00	3:30 PM	27.7	27.1	19.2	15.1	757.74	7	0.908
20-Oct-00	4:00 PM	0	20.7	23.9	15.8	759.25	7.9	0.908
20-Oct-00	4:30 PM	35.9	25.4	23.9	15.8	761.25	8.1	0.908
20-Oct-00	5:00 PM	40.3	37.4	31.4	16.6	764.25	8	0.907
20-Oct-00	5:30 PM	27.5	30.5	31.4	16.6	766.65	7.9	0.907
20-Oct-00	6:00 PM	27.5	14.2	22.3	16.9	767.63	7.4	0.907
20-Oct-00	6:30 PM	29.3	30.4	22.3	16.9	770.02	6.9	0.906
20-Oct-00	7:00 PM	35.4	36.3	33.4	17.3	772.93	6.7	0.906
20-Oct-00	7:30 PM	16.7	21.3	33.4	17.3	774.53	6.7	0.906
20-Oct-00	8:00 PM	35.8	34	27.7	17.5	777.25	6.5	0.905
20-Oct-00	8:30 PM	36.8	34	27.7	17.5	779.97	6.7	0.905
20-Oct-00	9:00 PM	8.1	16.2	25.1	17.4	781.11	7	0.904
20-Oct-00	9:30 PM	31.3	30	25.1	17.4	783.47	6.6	0.904
20-Oct-00	10:00 PM	21.3	24.3	27.1	17	785.32	6.4	0.905
20-Oct-00	10:30 PM	11.6	11.6	27.1	17	786.08	5.4	0.905
20-Oct-00	11:00 PM	24.5	25.6	18.6	16.7	788.05	4.9	0.905
20-Oct-00	11:30 PM	23.7	23.8	18.6	16.7	789.88	4.5	0.905
21-Oct-00	12:00 AM	15	10.4	17.1	16.5	790.52	3.6	0.906
21-Oct-00	12:30 AM	29	28	17.1	16.5	792.71	3.9	0.906
21-Oct-00	1:00 AM	12.9	30.5	29.3	17.3	795.08	3.2	0.906
21-Oct-00	1:30 AM	34	23.7	29.3	17.3	796.93	2.9	0.906
21-Oct-00	2:00 AM	5.9	30.7	27.2	18	799.31	2.7	0.907
21-Oct-00	2:30 AM	31.9	22.2	27.2	18	801.03	2.6	0.908
21-Oct-00	3:00 AM	0	23.3	22.8	18.6	802.78	3.1	0.908
21-Oct-00	3:30 AM	28.2	24.1	22.8	18.6	804.65	3.5	0.909
21-Oct-00	4:00 AM	0	12.9	18.5	19.1	805.48	2.8	0.909
21-Oct-00	4:30 AM	23	18.4	18.5	19.1	806.85	3.1	0.91
21-Oct-00	5:00 AM	0	2.7	10.5	19.1	806.8	3.1	0.911
21-Oct-00	5:30 AM	14.8	13.2	10.5	19.1	807.71	3.3	0.911
21-Oct-00	6:00 AM	0	3.3	8.2	19.4	807.71	3.3	0.912
21-Oct-00	6:30 AM	12.4	9	8.2	19.4	808.26	3.4	0.913
21-Oct-00	7:00 AM	0	6.4	7.7	19.3	808.53	3.5	0.913
21-Oct-00	7:30 AM	10.7	2.9	7.7	19.3	808.54	3.2	0.914
21-Oct-00	8:00 AM	0	7.8	5.3	19.4	808.93	2.7	0.914
21-Oct-00	8:30 AM	11.6	1.9	5.3	19.4	808.87	3.4	0.915
21-Oct-00	9:00 AM	0	4.5	3.2	19	808.96	3.6	0.915
21-Oct-00	9:30 AM	13.9	5.7	3.2	19	809.24	4	0.916
21-Oct-00	10:00 AM	25	17.2	11.5	19.1	810.49	4.2	0.916
21-Oct-00	10:30 AM	13.6	0	11.5	19.1	810.07	4.4	0.917
21-Oct-00	11:00 AM	10.8	14.5	6.4	18.8	811.07	4.5	0.917
21-Oct-00	11:30 AM	7.9	0	6.4	18.8	810.72	5.4	0.918

236

21-Oct-00	12:00 PM	12.6	14	6.5	18.3	811.67	6.1	0.918
21-Oct-00	12:30 PM	6.9	8.8	6.5	18.3	812.18	8.1	0.918
21-Oct-00	1:00 PM	5.2	0	2.5	17.6	811.59	10.8	0.918
21-Oct-00	1:30 PM	8.9	9.5	2.5	17.6	812.15	10.3	0.918
21-Oct-00	2:00 PM	10	9.8	9.6	17.3	812.74	9.8	0.919
21-Oct-00	2:30 PM	19.5	13.1	9.6	17.3	813.63	7.7	0.919
21-Oct-00	3:00 PM	11.1	13.1	13.1	17	814.5	7.7	0.919
21-Oct-00	3:30 PM	11.5	11	13.1	17	815.21	7.7	0.92
21-Oct-00	4:00 PM	2.1	0	4.6	16.2	814.78	10.9	0.92
21-Oct-00	4:30 PM	7.8	11	4.6	16.2	815.47	10.6	0.921
21-Oct-00	5:00 PM	15.3	13	12	15.4	816.35	6.6	0.921
21-Oct-00	5:30 PM	9.9	12.8	12	15.4	817.21	6	0.922
21-Oct-00	6:00 PM	7.5	0.3	6.5	14.8	816.97	5.1	0.923
21-Oct-00	6:30 PM	13.4	14.8	6.5	14.8	818	3.9	0.923
21-Oct-00	7:00 PM	0	4.8	9.8	13.8	818.14	2.8	0.924
21-Oct-00	7:30 PM	15.8	13.7	9.8	13.8	819.1	2.2	0.924
21-Oct-00	8:00 PM	0	9	11.4	13.1	819.59	1.6	0.925
21-Oct-00	8:30 PM	15.8	9.7	11.4	13.1	820.21	0.9	0.925
21-Oct-00	9:00 PM	0	9.4	9.6	12.5	820.75	-0.1	0.926
21-Oct-00	9:30 PM	21.1	15.9	9.6	12.5	821.9	-1.2	0.926
21-Oct-00	10:00 PM	0	12.9	14.4	11.9	822.76	-0.3	0.927
21-Oct-00	10:30 PM	27.7	24.8	14.4	11.9	824.68	-1.1	0.927
21-Oct-00	11:00 PM	21.3	14.2	19.5	12	825.66	-2	0.928
21-Oct-00	11:30 PM	0	11.2	19.5	12	826.36	-2.3	0.928
22-Oct-00	12:00 AM	18.7	16.4	13.8	11.8	827.54	-2.2	0.928
22-Oct-00	12:30 AM	15.1	4.5	13.8	11.8	827.67	-2.5	0.928
22-Oct-00	1:00 AM	0	4.9	4.7	10.8	827.83	-2.4	0.928
22-Oct-00	1:30 AM	0	14.4	4.7	10.8	828.79	-2.3	0.929
22-Oct-00	2:00 AM	16.3	6.2	10.3	10.1	829.11	-3.1	0.929
22-Oct-00	2:30 AM	10.1	1.6	10.3	10.1	828.99	-4	0.929
22-Oct-00	3:00 AM	0	5	3.3	9.3	829.16	-5.4	0.929
22-Oct-00	3:30 AM	22.5	18.9	3.3	9.3	830.53	-5.5	0.929
22-Oct-00	4:00 AM	15.1	0	9.3	8.9	830.27	-6.2	0.929
22-Oct-00	4:30 AM	4.8	2.1	9.3	8.9	830.19	-5.6	0.929
22-Oct-00	5:00 AM	0	5.7	3.9	8.6	830.42	-5.6	0.929
22-Oct-00	5:30 AM	0	14.5	3.9	8.6	831.4	-4.4	0.928
22-Oct-00	6:00 AM	12.3	3.4	9	8.7	831.47	-4.4	0.928
22-Oct-00	6:30 AM	14.2	1.3	9	8.7	831.32	-4.9	0.928
22-Oct-00	7:00 AM	9.4	2.5	1.9	8.4	831.29	-4.1	0.927
22-Oct-00	7:30 AM	0.4	3.5	1.9	8.4	831.33	-3.4	0.927
22-Oct-00	8:00 AM	0	4.8	4.2	8.4	831.47	-2.4	0.927
22-Oct-00	8:30 AM	12.8	14.4	4.2	8.4	832.46	-2.2	0.927
22-Oct-00	9:00 AM	18	2.6	8.5	8.6	832.46	-0.3	0.927
22-Oct-00	9:30 AM	8.8	0.9	8.5	8.6	832.27	1.8	0.927
22-Oct-00	10:00 AM	14.9	19.2	10	8.5	833.68	3.4	0.927
22-Oct-00	10:30 AM	21.2	4.6	10	8.5	833.84	4.9	0.927
22-Oct-00	11:00 AM	16.2	17.7	11.2	8.7	835.11	7.4	0.927
22-Oct-00	11:30 AM	18.2	16.1	11.2	8.7	836.26	8.3	0.926
22-Oct-00	12:00 PM	12.4	15.6	15.8	9.1	837.35	9.1	0.926
22-Oct-00	12:30 PM	13	13.9	15.8	9.1	838.31	11.7	0.927
22-Oct-00	1:00 PM	19.1	13.1	13.5	9.6	839.21	13.7	0.927
22-Oct-00	1:30 PM	10.1	14.6	13.5	9.6	840.2	14.5	0.927
22-Oct-00	2:00 PM	6.7	8.9	11.8	9.7	840.71	13.6	0.927
22-Oct-00	2:30 PM	10.9	12.2	11.8	9.7	841.53	11.6	0.926
22-Oct-00	3:00 PM	14.8	15.9	14.1	9.7	842.66	11.3	0.926
22-Oct-00	3:30 PM	16.7	16.1	14.1	9.7	843.8	12.2	0.926
22-Oct-00	4:00 PM	17.1	17.7	16.9	10.2	845.09	14.4	0.925
22-Oct-00	4:30 PM	18.5	18.7	16.9	10.2	846.46	16.3	0.925
22-Oct-00	5:00 PM	20.6	19.8	19.2	10.5	847.92	12.3	0.925
22-Oct-00	5:30 PM	20	20.1	19.2	10.5	849.43	11.7	0.925
22-Oct-00	6:00 PM	23.7	22.7	21.4	11.1	851.15	10.4	0.925
22-Oct-00	6:30 PM	27.4	28.7	21.4	11.1	853.39	9.9	0.925

237

22-Oct-00	7:00 PM	29.6	27.9	28.3	11.9	855.57	8.8	0.925
22-Oct-00	7:30 PM	0	23.4	28.3	11.9	857.32	8	0.925
22-Oct-00	8:00 PM	30.4	21.7	22.6	12.4	858.99	6.2	0.925
22-Oct-00	8:30 PM	28.9	27.9	22.6	12.4	861.16	6.3	0.925
22-Oct-00	9:00 PM	9.9	27.4	27.6	13.1	863.24	6.3	0.925
22-Oct-00	9:30 PM	26.6	12.9	27.6	13.1	864.16	5.2	0.925
22-Oct-00	10:00 PM	23	25.8	19.4	13.3	866.15	5.3	0.925
22-Oct-00	10:30 PM	0	8.8	19.4	13.3	866.64	4.5	0.925
22-Oct-00	11:00 PM	18	17.1	13	13.1	867.88	4.9	0.925
22-Oct-00	11:30 PM	15.7	17.7	13	13.1	869.16	5.4	0.926
23-Oct-00	12:00 AM	8.7	0	8.3	12.8	868.8	4.4	0.925
23-Oct-00	12:30 AM	14.4	14.9	8.3	12.8	869.84	2.8	0.926
23-Oct-00	1:00 AM	0	8.3	11.6	13.1	870.27	2.1	0.926
23-Oct-00	1:30 AM	17.9	7.4	11.6	13.1	870.69	2.2	0.926
23-Oct-00	2:00 AM	25.2	20.1	13.7	13.3	872.19	4.3	0.926
23-Oct-00	2:30 AM	13.9	0	13.7	13.3	871.76	4.1	0.927
23-Oct-00	3:00 AM	13.5	14.5	6.3	13.4	872.77	3.5	0.927
23-Oct-00	3:30 AM	0	0	6.3	13.4	872.38	3.1	0.927
23-Oct-00	4:00 AM	14.3	14.2	6.4	13.3	873.36	3.8	0.927
23-Oct-00	4:30 AM	0	1.5	6.4	13.3	873.22	3	0.927
23-Oct-00	5:00 AM	15.3	10.4	6	13.4	873.89	2.2	0.927
23-Oct-00	5:30 AM	22.7	16.2	6	13.4	875.07	3.6	0.927
23-Oct-00	6:00 AM	15.4	0	8.1	13.3	874.78	1.9	0.927
23-Oct-00	6:30 AM	20	20.8	8.1	13.3	876.33	1.5	0.928
23-Oct-00	7:00 AM	11.7	2.1	11.4	13.7	876.25	1.6	0.927
23-Oct-00	7:30 AM	20.2	20.2	11.4	13.7	877.76	1.4	0.928
23-Oct-00	8:00 AM	5.2	8.1	14.2	14.1	878.21	1.3	0.928
23-Oct-00	8:30 AM	37.8	31.9	14.2	14.1	880.74	0.8	0.928
23-Oct-00	9:00 AM	23	21.1	26.5	14.9	882.32	3	0.928
23-Oct-00	9:30 AM	37	38.4	26.5	14.9	885.42	3.2	0.929
23-Oct-00	10:00 AM	40.2	39.8	39.1	16.1	888.63	7.5	0.928
23-Oct-00	10:30 AM	39.8	40.7	39.1	16.1	891.94	11.6	0.929
23-Oct-00	11:00 AM	31.9	46.9	43.8	17.5	895.76	15.9	0.929
23-Oct-00	11:30 AM	6.6	10.5	43.8	17.5	896.41	16.7	0.929
23-Oct-00	12:00 PM	17.3	13.4	12	17.3	897.33	15.2	0.93
23-Oct-00	12:30 PM	16.7	17	12	17.3	898.55	18.7	0.929
23-Oct-00	1:00 PM	4.2	9.4	13.2	17.3	899.09	23.1	0.929
23-Oct-00	1:30 PM	0.2	2.7	13.2	17.3	899.07	23.8	0.93
23-Oct-00	2:00 PM	9.3	3.8	3.3	16.9	899.15	22.1	0.929
23-Oct-00	2:30 PM	8	7.6	3.3	16.9	899.55	17.8	0.929
23-Oct-00	3:00 PM	14.4	12.1	9.8	16.8	900.35	16.3	0.929
23-Oct-00	3:30 PM	26.9	22.1	9.8	16.8	902.01	16	0.929
23-Oct-00	4:00 PM	12.4	13.3	17.7	16.8	902.9	17	0.929
23-Oct-00	4:30 PM	11.5	14	17.7	16.8	903.86	16.8	0.928
23-Oct-00	5:00 PM	12.1	13.3	13.6	16.6	904.76	14.7	0.928
23-Oct-00	5:30 PM	21.8	20.6	13.6	16.6	906.31	13.2	0.928
23-Oct-00	6:00 PM	25.5	25.5	23.1	16.6	908.28	12.1	0.928
23-Oct-00	6:30 PM	28.2	29.1	23.1	16.6	910.56	10.7	0.928
23-Oct-00	7:00 PM	38.3	35.6	32.3	16.8	913.41	9.9	0.928
23-Oct-00	7:30 PM	46.3	36.4	32.3	16.8	916.34	9.3	0.927
23-Oct-00	8:00 PM	49.6	46.8	41.6	17.6	920.17	8.1	0.927
23-Oct-00	8:30 PM	83.8	79.1	41.6	17.6	926.83	8	0.927
23-Oct-00	9:00 PM	75.6	75	77	19.6	933.11	6.3	0.927
23-Oct-00	9:30 PM	43.4	44.6	77	19.6	936.74	5.6	0.927
23-Oct-00	10:00 PM	55.4	56.2	50.4	20.9	941.38	5	0.927
23-Oct-00	10:30 PM	50.1	53	50.4	20.9	945.75	4.4	0.927
23-Oct-00	11:00 PM	17.7	45.2	49.1	22.4	949.4	3.5	0.927
23-Oct-00	11:30 PM	57.2	48.9	49.1	22.4	953.44	2.5	0.927
24-Oct-00	12:00 AM	49.9	52.1	50.5	24.2	957.73	2.2	0.927
24-Oct-00	12:30 AM	28.4	32.5	50.5	24.2	960.31	2.2	0.926
24-Oct-00	1:00 AM	42.7	45.4	39	25.3	964.01	1.1	0.926
24-Oct-00	1:30 AM	18.6	32.7	39	25.3	966.6	1.8	0.926

24-Oct-00	2:00 AM	38.6	40.8	36.7	26.3	969.9	1.9	0.926
24-Oct-00	2:30 AM	24	24.9	36.7	26.3	971.81	1.6	0.926
24-Oct-00	3:00 AM	42.4	42.5	33.7	27.4	975.27	2.3	0.926
24-Oct-00	3:30 AM	11.4	34.7	33.7	27.4	978.02	2.3	0.927
24-Oct-00	4:00 AM	38.7	37.7	36.2	28.7	981.07	2.2	0.927
24-Oct-00	4:30 AM	0	27.9	36.2	28.7	983.22	2.4	0.927
24-Oct-00	5:00 AM	42.7	35.4	31.7	29.7	986.08	2.3	0.926
24-Oct-00	5:30 AM	56.1	46.1	31.7	29.7	989.87	1.4	0.927
24-Oct-00	6:00 AM	47.9	29.2	37.7	31	992.15	0.8	0.927
24-Oct-00	6:30 AM	50.5	48.6	37.7	31	996.1	0.7	0.927
24-Oct-00	7:00 AM	43	22.7	35.6	32	997.85	0.5	0.926
24-Oct-00	7:30 AM	47.5	45.2	35.6	32	1001.54	0.1	0.926
24-Oct-00	8:00 AM	39.6	20.3	32.7	32.8	1003.04	0.3	0.926
24-Oct-00	8:30 AM	39.7	41.1	32.7	32.8	1006.33	0.5	0.927
24-Oct-00	9:00 AM	47.3	32.4	36.8	33.2	1008.95	1	0.927
24-Oct-00	9:30 AM	36.4	42.1	36.8	33.2	1012.36	3.2	0.927
24-Oct-00	10:00 AM	30.6	17.9	30	32.8	1013.65	7.1	0.927
24-Oct-00	10:30 AM	30.4	35.9	30	32.8	1016.52	10.7	0.927
24-Oct-00	11:00 AM	20.6	22.6	29.2	32.2	1018.23	12.3	0.928
24-Oct-00	11:30 AM	20.7	22.1	29.2	32.2	1019.91	13.9	0.928
24-Oct-00	12:00 PM	28.5	26.7	24.4	32.7	1021.99	11.8	0.927
24-Oct-00	12:30 PM	46.3	40.1	24.4	32.7	1025.24	11.2	0.927
24-Oct-00	1:00 PM	43.7	46.3	43.2	34	1029.02	12	0.927
24-Oct-00	1:30 PM	46.2	45	43.2	34	1032.69	13.1	0.928
24-Oct-00	2:00 PM	25.9	33.1	39.1	35.5	1035.31	14.4	0.927
24-Oct-00	2:30 PM	23.6	23.8	39.1	35.5	1037.13	12.6	0.928
24-Oct-00	3:00 PM	28.8	30.4	27.1	36.2	1039.53	13.3	0.928
24-Oct-00	3:30 PM	26.5	25.5	27.1	36.2	1041.49	13.1	0.928
24-Oct-00	4:00 PM	27.6	28.9	27.2	36.6	1043.76	13.2	0.928
24-Oct-00	4:30 PM	20.5	24.3	27.2	36.6	1045.62	13.2	0.928
24-Oct-00	5:00 PM	24.7	26.1	25.2	37.1	1047.64	12.1	0.929
24-Oct-00	5:30 PM	23.1	24.2	25.2	37.1	1049.49	11.2	0.929
24-Oct-00	6:00 PM	22.5	24.5	24.4	37.1	1051.37	10.1	0.929
24-Oct-00	6:30 PM	19.3	20.1	24.4	37.1	1052.86	9.3	0.929
24-Oct-00	7:00 PM	25	24.2	22.1	36.7	1054.71	8.8	0.929
24-Oct-00	7:30 PM	15.2	19.4	22.1	36.7	1056.14	8.7	0.929
24-Oct-00	8:00 PM	9.1	1.3	10.4	35.4	1055.99	8.5	0.93
24-Oct-00	8:30 PM	16.9	18	10.4	35.4	1057.3	8.2	0.93
24-Oct-00	9:00 PM	14.3	17.6	17.8	32.9	1058.57	7.6	0.93
24-Oct-00	9:30 PM	12.1	14.5	17.8	32.9	1059.58	7.1	0.93
24-Oct-00	10:00 PM	0	1.8	8.1	31.2	1059.46	6.5	0.93
24-Oct-00	10:30 PM	19.4	15.5	8.1	31.2	1060.58	6	0.931
24-Oct-00	11:00 PM	20	22	18.8	29.9	1062.24	5.9	0.93
24-Oct-00	11:30 PM	0	8.7	18.8	29.9	1062.71	5.5	0.931
25-Oct-00	12:00 AM	19	15.3	12	28.3	1063.81	5.3	0.931
25-Oct-00	12:30 AM	18.8	21.6	12	28.3	1065.43	5.5	0.931
25-Oct-00	1:00 AM	0	6.3	13.9	27.3	1065.69	5.3	0.931
25-Oct-00	1:30 AM	14.9	8.9	13.9	27.3	1066.23	5.1	0.931
25-Oct-00	2:00 AM	12.6	16.1	12.5	26.2	1067.38	3.6	0.932
25-Oct-00	2:30 AM	0	0	12.5	26.2	1066.87	2.3	0.932
25-Oct-00	3:00 AM	17.1	12.6	5	25	1067.73	3	0.932
25-Oct-00	3:30 AM	9.9	13.5	5	25	1068.64	2.1	0.932
25-Oct-00	4:00 AM	10	0	4.8	23.7	1068.03	1.9	0.932
25-Oct-00	4:30 AM	14.7	16.7	4.8	23.7	1069.23	2.4	0.932
25-Oct-00	5:00 AM	0.1	0	7.4	22.7	1068.8	2.8	0.932
25-Oct-00	5:30 AM	17.3	16	7.4	22.7	1069.93	2.7	0.932
25-Oct-00	6:00 AM	0	1.6	8.8	21.5	1069.8	3	0.932
25-Oct-00	6:30 AM	19.2	14.3	8.8	21.5	1070.8	3.2	0.932
25-Oct-00	7:00 AM	17.2	19	16.6	20.7	1072.2	3.3	0.932
25-Oct-00	7:30 AM	14.4	2	16.6	20.7	1072.11	3.4	0.932
25-Oct-00	8:00 AM	22.1	22.7	12.3	19.9	1073.84	3.6	0.932
25-Oct-00	8:30 AM	0	5.3	12.3	19.9	1074.03	3.3	0.932

25-Oct-00	9:00 AM	26.5	21.1	13.2	18.9	1075.63	3.6	0.932
25-Oct-00	9:30 AM	17.8	23.1	13.2	18.9	1077.37	4.1	0.932
25-Oct-00	10:00 AM	12.8	1	12.1	18.2	1077.2	4.5	0.932
25-Oct-00	10:30 AM	21.4	20.9	12.1	18.2	1078.76	5.4	0.932
25-Oct-00	11:00 AM	19.7	21.1	21	17.8	1080.34	6.5	0.932
25-Oct-00	11:30 AM	3.9	4	21	17.8	1080.43	6.6	0.932
25-Oct-00	12:00 PM	23.1	22.4	13.2	17.3	1082.13	7.2	0.932
Average		15.21	14.64	14.57	14.39		3.78	
Std Dev		12.45	11.38	10.41	7.60		6.58	

8.3   Meteorological Data

August 2000

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE METEOROLOGIQUE MENSUEL

Environment Canada
Environnement Canada
Prairie & Northern Region
Région des Prairies et du Nord

EDMONTON INTL ARPRT, AB.
MONTH/MOIS: AUGUST/août 2000

DATE	TEMPERATURE TEMPERATURE			DEGREE-DAYS DEGRES-JOURS			REL HUMIDITY HUMIDITE REL		PRECIPITATION PRECIPITATIONS			SNOW ON GROUND
	MAX	MIN	MEAN moyenne	HEATING de chauffe	GROWING de crois-sance	COOLING de refri-geration	MAX	MIN	RAINFALL de pluie hauteur	SNOWFALL de neige hauteur	TOTAL precip-totales	neige au sol
	°C	°C	°C	base 18	base 5	base 18	%	%	mm	cm	mm	cm
1	21.9	12.0	17.0	1.0	12.0		89	55	0.6	0.0	0.6	0
2	19.6	6.1	12.9	5.1	7.9		92	68	TR	0.0	TR	0
3	22.3	9.9	16.1	1.9	11.1		92	63	0.0	0.0	0.0	0
4	24.5	7.6	16.1	1.9	11.1		93	57	0.0	0.0	0.0	0
5	27.1	10.2	18.7		13.7	0.7	92	45	0.0	0.0	0.0	0
6	23.5	12.2	17.9	0.1	12.9		87	64	6.2	0.0	6.2	0
7	21.9	9.2	15.6	2.4	10.6		92	57	0.2	0.0	0.2	0
8	22.0	6.8	14.4	3.6	9.4		93	59	0.0	0.0	0.0	0
9	22.9	11.4	17.2	0.8	12.2		87	57	0.0	0.0	0.0	0
10	21.2	11.8	16.5	1.5	11.5		91	49	0.6	0.0	0.6	0
11	17.3	10.6	14.0	4.0	9.0		100	49	4.2	0.0	4.2	0
12	20.0	4.1	12.1	5.9	7.1		93	45	0.2	0.0	0.2	0
13	17.6	7.3	12.5	5.5	7.5		92	63	2.4	TR	2.4	0
14	19.9	2.7	11.3	6.7	6.3		91	44	0.0	0.0	0.0	0
15	23.8	6.4	15.1	2.9	10.1		87	39	0.0	0.0	0.0	0
16	17.4	5.5	11.5	6.5	6.5		91	65	TR	0.0	TR	0
17	23.4	4.3	13.9	4.1	8.9		92	47	0.0	0.0	0.0	0
18	24.3	6.5	15.4	2.6	10.4		88	49	0.0	0.0	0.0	0
19	20.9	9.4	15.2	2.8	10.2		87	45	5.4	0.0	5.4	0
20	20.4	4.4	12.4	5.6	7.4		86	37	TR	0.0	TR	0
21	21.7	2.9	12.3	5.7	7.3		85	35	0.0	0.0	0.0	0
22	25.2	5.2	15.2	2.8	10.2		86	36	0.0	0.0	0.0	0
23	27.4	5.4	16.4	1.6	11.4		92	39	TR	0.0	TR	0
24	25.2	11.0	18.1		13.1	0.1	91	47	0.0	0.0	0.0	0
25	26.6	12.7	19.7		14.7	1.7	90	43	0.0	0.0	0.0	0
26	16.5	5.5	11.0	7.0	6.0		93	55	1.4	0.0	1.4	0
27	14.3	3.6	9.0	9.0	4.0		84	50	0.0	0.0	0.0	0
28	17.1	2.3	9.7	8.3	4.7		89	42	TR	0.0	TR	0
29	9.9	6.6	8.3	9.7	3.3		90	80	6.8	0.0	6.8	0
30	10.9	5.7	8.3	9.7	3.3		91	66	4.4	0.0	4.4	0
31	12.5	5.0	8.8	9.2	3.8		89	68	TR	0.0	TR	0
TOTAL				127.9	277.6	2.5			32.4	0.0	32.4	totale
MEAN	20.6	7.2	13.9				90	52				moyenne
NORMAL	21.8	8.2	15.0	104.5	310.1	11.6			69.5	0.0	69.5	nomale

NOTE/AVIS:
1. Climatological Day / Journee Climatololoque 23 01 MST - 23 00 MST
2. 30 Year Normals / Normales duree 30 ans.
3. TR - Trace

242

EDMONTON INTL ARPRT, AB.　　　　　　*MONTH/MOIS:　AUGUST/août　2000*

DRYBULB TEMPERATURES / TEMPERATURES DU THERMOMETRE SEC

DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	188	174	156	148	141	138	157	175	201	205	207	203	194	186	196	202	204	185	177	169	135	132	128	120
2	101	92	91	73	75	90	91	118	138	151	157	158	164	156	180	189	182	186	190	177	166	152	138	135
3	126	115	101	114	131	120	117	146	160	166	171	178	194	200	211	219	202	214	211	204	178	133	124	109
4	109	100	98	84	90	85	92	132	157	184	203	207	219	226	240	224	226	226	229	215	183	169	151	146
5	135	132	121	102	124	127	128	163	190	211	221	239	248	256	264	266	269	262	265	248	197	179	166	162
6	156	181	165	162	160	131	135	165	201	223	228	235	212	207	207	195	183	185	186	178	168	158	151	151
7	146	142	134	127	112	120	117	127	130	140	154	168	174	196	207	212	202	192	163	149	153	116	102	93
8	94	106	102	84	81	80	98	125	140	162	175	184	197	203	208	200	212	207	201	175	155	160	143	140
9	135	129	130	124	118	119	117	135	152	175	191	192	207	218	225	211	225	221	210	195	182	159	131	142
10	138	135	126	120	124	123	124	129	132	140	151	164	182	193	200	209	209	210	201	186	171	143	153	141
11	127	132	139	137	137	137	135	130	131	142	157	149	149	146	148	166	166	171	165	156	135	117	112	106
12	97	93	84	67	50	41	50	88	106	126	146	160	173	184	180	192	199	193	187	164	136	104	110	98
13	107	98	101	96	87	105	111	111	128	139	154	156	138	148	140	158	162	145	137	122	112	103	103	76
14	64	59	44	54	30	32	37	62	93	121	147	158	166	183	184	178	182	190	189	174	132	99	81	73
15	64	68	77	72	69	69	80	102	145	172	188	207	213	217	223	231	214	213	186	175	157	119	108	102
16	112	127	91	92	89	96	93	108	125	134	140	146	153	154	159	153	168	166	153	132	112	100	81	55
17	61	57	63	98	99	105	109	113	119	125	148	166	182	193	206	222	232	233	226	200	163	164	160	148
18	146	136	125	108	88	78	67	100	136	158	181	194	209	222	231	236	240	237	233	188	145	149	144	139
19	122	112	112	128	122	120	115	117	147	159	167	176	192	196	197	195	197	163	166	145	105	95	104	96
20	99	99	90	58	72	53	45	81	109	135	160	171	175	188	192	186	208	206	202	151	112	94	79	72
21	73	74	68	66	53	35	45	71	128	139	171	186	198	200	198	212	250	247	211	213	163	93	104	94
22	71	67	69	61	67	60	64	98	142	189	215	230	237	238	234	249	250	247	251	239	163	126	106	99
23	101	78	68	65	65	62	65	107	146	184	200	229	243	252	252	258	262	258	251	200	177	151	169	153
24	141	133	141	113	146	159	150	176	182	202	203	210	210	226	234	236	242	239	224	204	194	175	177	175
25	158	169	159	167	155	142	128	135	158	189	202	217	235	243	256	249	253	246	238	200	169	162	151	137
26	117	101	85	135	119	106	104	106	117	140	150	151	139	143	105	136	155	159	154	117	92	83	57	79
27	83	102	87	66	42	38	53	84	105	117	122	124	135	143	136	130	120	118	115	109	95	73	87	84
28	90	88	78	46	50	30	27	62	96	100	108	114	137	148	155	150	167	152	146	118	106	98	92	99
29	95	89	82	79	76	73	72	71	72	69	77	81	85	89	87	83	82	79	76	73	70	70	66	67
30	67	66	65	82	63	62	58	62	66	69	78	76	84	95	98	101	106	107	107	90	70	65	59	63
31	66	60	59	60	51	54	54	69	83	89	92	99	99	99	104	109	115	125	123	116	107	98	99	99

HOUR / HEURE

NOTE/AVIS:　　1. Unit = 0.1 C　　1. Unité = 0.1 C
　　　　　　　2. No entry = Missing / Pas de aleur - Manquant

PRECIPITATION OCCURRENCES / ÉVÉNEMENT DES PRÉCIPITATIONS

HOUR / HEURE

DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1																					TRW			
2																								
3								RW																
4																								
5	TRW	TRW																						
6													RW			RW	RW							
7																			T					
8																								
9																							TRW	
10																						RW		
11	RW						RW	RW						RW	RW									
12						TRW	TRW						TRW											
13																								
14																								
15																RW								
16																								
17																								
18																		TRW						
19																				TRW				
20																								
21																								
22																								
23																								
24																								
25														RW	RW									
26																								
27																								R
28																								R
29	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R	R
30	R	R											L	L										
31																								RW

244

WINDS (kmh) / DES VENTS (km/h)

HOUR / DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Peak Gust / Rafale	Hour Heure
1	E	ESE	SE	ESE	ESE	ESE	SE	SSE	SSE	SSW	W	WNW	NNW	NW	NNW	N	N	N	NW	NW	NNW	NE	WNW	WSW	NNW	1400
1	11	9	6	13	11	9	9	7	11	15	13	13	32	30	30	20	22	19	9	15	15	9	7	6	46	
2	W	WSW	SW	W	C	WSW	C	SSW	W	W	W	W	W	WNW	W	WNW	W	NW	WNW	WNW	W	WNW	W	W	W	
2	7	6	7	4	0	6	0	4	4	15	19	20	19	9	15	15	19	20	17	15	15	9	9	7		
3	W	WSW	WSW	W	W	W	W	W	WNW	WNW	NW	WNW	WNW	WNW	NW	WNW	NW	NW	WNW	WNW	N	C	C	N		
3	11	9	7	6	7	7	6	15	17	11	11	15	17	17	17	13	11	17	11	9	9	0	0	4		
4	SSW	SSW	C	SSW	SW	SW	C	C	WSW	C	SSW	C	NW	C	SSW	NW	NNW	NE	NE	E	ESE	SSW	S	S		
4	6	4	0	6	4	4	0	0	7	0	4	0	7	0	7	7	4	7	7	7	4	7	7	7		
5	S	S	S	S	SW	SW	SW	W	W	W	W	W	WNW	W	W	WNW	WNW	NW	WNW	WNW	SE	S	S	S		
5	9	6	7	6	9	6	4	7	9	7	11	9	15	17	19	20	15	9	6	4	6	9	11	9		
6	S	N	E	SE	S	ESE	SSW	S	S	WSW	WNW	NW	NW	NNW	WNW	W	WNW	W	W	NW	NW	WNW	NW	NNW	WNW	1300
6	9	6	11	15	7	4	17	9	15	13	17	17	19	24	26	24	19	19	9	22	13	9	9	9	46	
7	NW	WNW	WNW	W	WNW	NW	WSW	NW	NE	C	SW	WSW	C	W	W	NW	W	NNW	NNW	C	W	WSW	W	SW		
7	9	6	7	7	4	6	7	6	4	0	6	6	0	6	7	9	7	11	17	0	4	7	7	4		
8	W	W	W	W	W	W	W	W	NW	NW	NW	NNW	W	N	NW	N	N	N	N	N	N	N	NNE	N		
8	7	7	7	7	7	7	7	7	15	17	15	7	13	7	11	11	11	13	17	11	9	11	6	9		
9	N	NNE	ENE	E	ENE	NE	E	E	ESE	ESE	ESE	SE	ESE	ESE	ESE	E	E	E	ENE	ENE	ENE	NE	NNE	N	ESE	1500
9	9	7	7	4	7	6	9	13	17	19	20	24	20	24	24	22	22	28	24	22	19	11	11	13	46	
10	NNW	NE	N	N	N	NNW	NNW	WNW	WNW	WNW	WNW	NNW	N	NE	NE	NE	NE	NE	ENE	E	ENE	NNE	NE	N		
10	20	11	7	7	7	9	9	11	9	9	9	9	7	15	17	15	17	15	24	11	11	13	13	13		
11	ENE	NNE	NNE	NE	E	E	N	NNE	NE	ESE	NE	NNE	NNW	NE	N	N	N	N	WNW	WNW		NW	WNW	WNW	WNW	2300
11	4	9	17	22	11	7	17	15	19	11	6	7	7	11	19	15	11	7	6	9		15	20	19	33	
12	WNW	W	NW	W	WSW	WSW	WSW	WSW	W	W	W	WNW	WSW	WNW	WNW	W	W	WSW	SW	S	S	SSE	S	SSW		
12	13	9	7	9	9	6	7	7	7	9	15	9	9	19	15	6	6	6	6	7	7	7	11	7		
13	S	SSE	SSE	S	S	S	WNW	S	E	NNE	NNW	NNW	C	NNW	NW	NW	NW	WNW	WNW	W	W	W	W	N	N	1500
13	6	4	6	4	7	7	7	6	4	7	6	0	11	20	7	11	13	13	17	13	9	9	9	7	32	
14	W	W	W	W	W	WSW	WSW	WSW	W	W	WSW	WSW	W	W	WNW	WNW	W	NW	C	S	S	S	S	WNW	WNW	1500
14	9	9	7	7	7	7	6	7	6	13	13	13	15	13	20	15	15	15	9	0	7	11	11	11	32	
15	S	S	S	S	S	S	S	S	S	S	S	S	SSE	SSE	W	W	WNW	WNW	WNW	W	W	W	W			
15	13	11	13	13	15	13	11	13	11	19	24	19	19	22	9	4	11	11	7	7	11	7	6	7		
16	NW	N	W	W	WNW	WNW	WNW	WNW	NW	NNW	NW	NW	N	N	N	NNW	N	NNW	N	NE	NE	ENE	C	ENE		
16	11	13	7	15	7	13	15	9	11	9	15	13	11	11	13	13	11	13	11	7	11	11	0	6		
17	C	C	SE	C	SE	SE	SE	SE	SSE	SE	SE	SE	SSE	SSE	SSE	SSE	SSE	SE	SE	ESE	ESE	ESE	SE	SSE	SSE	1600
17	0	0	6	0	7	11	17	17	22	19	20	26	26	22	19	26	22	24	24	17	15	24	24	19	46	
18	SE	SE	SE	SE	SSE	SE	WSW	S	S	SSE	C	ESE	ESE	SE	SE	SSE	S	S	E	NE	NNW	NNE	NW			
18	20	17	13	11	11	11	4	7	9	6	0	7	4	9	11	15	9	7	4	6	9	15	9	6		
19	NNW	W	W	WNW	WNW	WNW	WNW	C	WSW	W	WNW	W	NNW	WNW	WNW	NNW	W	WNW	NW	WNW	SSW	S	SW	S	NW	1800
19	9	15	7	20	15	15	0	7	15	17	17	13	9	15	11	9	11	13	6	17	7	15	9	11	48	
20	SW	SW	SW	WSW	W	WSW	W	W	W	W	WNW	WNW	WNW	W	W	WNW	WNW	NW	W	WNW	NW	SSW	SSW	SSW	W	1400
20	7	9	9	6	7	6	9	13	15	17	19	19	17	17	11	15	15	7	11	6	7	9	11	7	33	
21	SSW	SSW	WSW	SW	SSW	S	SSW	SSW	SW	WSW	WSW	WNW	W	WNW	W	WSW	W	WNW	NW	C	SSE	SSE	S	S	WNW	1400
21	7	9	7	9	7	9	9	6	6	15	9	15	22	17	22	17	17	11	4	0	4	6	9	9	41	
22	WSW	SSW	S	SSW	SSW	S	SSW	SSW	S	S	SSW	SSW	S	S	S	S	S	SSW	SSW	S	S	C	NE	ENE	ESE	
22	6	7	9	7	9	7	13	13	6	7	13	13	15	13	13	11	13	11	7	6	0	6	6	4		
23	ESE	SW	SW	SW	NW	W	C	W	C	N	WNW	ENE	E	WNW	NNW	NNW	C	C	C	C	NNE	C	NE	NW		
23	4	4	4	9	6	6	0	4	0	6	6	6	7	4	4	4	0	0	0	0	4	0	11	6		
24	W	C	WNW	W	NW	W	NNE	NE	NW	NW	W	W	N	NE	N	N	NE	N	ENE	E	E	ENE	ESE	E	NNW	600
24	4	0	6	6	19	20	9	9	4	6	9	6	7	7	7	7	7	4	9	11	11	6	13	13	37	
25	SE	SE	SE	SE	W	C	C	C	C	C	SSE	C	SE	NNW	NW	NE	NNE	N	ESE	ESE	E	ESE	SE	S		
25	6	11	15	17	7	6	0	0	0	0	6	6	0	6	9	4	6	4	6	6	13	11	11	13		
26	SW	SSW	C	NW	NW	WNW	WNW	NW	WNW	NNW	NNW	NW	NNW	WNW	W	W	W	W	WNW	N	SSW	SSW	S	SSW	NW	1200
26	4	4	0	15	11	15	13	9	19	17	24	26	30	15	15	11	13	9	7	11	13	11	11	13	43	
27	WSW	W	W	SW	SSW	SSW	SW	W	WNW	W	W	W	WNW	WNW	WNW	WNW	WNW	WNW	WNW	WNW	WNW	W	WNW	W	WNW	1300
27	9	11	9	6	9	9	13	19	26	28	30	35	39	35	28	39	39	24	24	30	24	9	15	6	56	
28	W	W	WNW	W	W	W	SW	W	WNW	NW	WNW	WNW	WNW	NW	NW	NW	NNW	N	N	NNW	N	N	NNW	WNW	WNW	1400
28	17	17	15	7	11	7	7	7	13	17	17	13	13	22	20	19	15	13	11	7	4	4	7	7	32	
29	N	NE	NE	NE	N	NE	NE	ENE	E	E	E	E	E	E	ENE	E	ENE	E	ENE	ENE	ENE	NNE	NE		ENE	
29	4	9	7	6	15	11	11	7	15	13	13	7	20	15	19	13	15	17	11	11	9	7	7		7	
30	NNE	NNE	N	N	NNE	NE	NE	NE	E	E	SE	S	C	C	S	SSE	S	S	S	SSE	SSE	SSE	SE	SSE		
30	9	7	9	7	7	7	6	4	7	6	4	0	0	7	11	13	13	15	17	9	11	13	13	17		
31	SSE	SE	SE	SE	SE	SE	ESE	ESE	ESE	ESE	ESE	SE	ESE	ESE	SE	ESE	ESE	ESE	ESE	ESE	E	E	E	ENE	SSW	1500
31	17	17	17	19	15	15	19	17	19	24	26	26	24	22	26	22	26	22	20	19	9	7	11	9	44	

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Pdir	ESE	W	WNW	SSW	S	NW	W	N	ESE	NE	N	WSW	S	W	S	
Avg V	14	11	10	4	10	14	6	10	16	12	12 *	9	8	10	12	
dir 2					W							W				

DATE	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Pdir	N	SE	SE	WNW	WNW	SSW	S	SW	N	SE	WNW	WNW	WNW	E	SSE	ESE	
Avg V	11	16	9	12	11	10	10	4	8	7	13	22	12	12	9	19	
dir 2													W				

NOTE/AVIS: Pdir = Prevailing direcation/Direction dominante

dir2 = 2nd Prevailing direction

* = indicates/indique < 24 hrs and/et >= 18hrs

October 2000

MONTHLY METEOROLOGICAL SUMMARY
SOMMAIRE METEOROLOGIQUE MENSUEL

EDMONTON INTL ARPRT, AB.   **MONTH/MOIS: OCTOBER/octobre 2000**

DATE	TEMPERATURE TEMPERATURE			DEGREE-DAYS DEGRES-JOURS			REL HUMIDITY HUMIDITE REL		PRECIPITATION PRECIPITATIONS			SNOW ON GROUND
	MAX	MIN	MEAN	HEATING	GROWING	COOLING	MAX	MIN	RAINFALL	SNOWFALL	TOTAL	
			moyenne	de chauffe	de crois-sance	de refri-geration			de pluie hauteur	de neige hauteur	precip-totales	neige au sol
	°C	°C	°C	base 18	base 5	base 18	%	%	mm	cm	mm	cm
1	10.9	-3.7	3.6	14.4			87	38	1.0	0.0	1.0	0
2	5.1	-2.9	1.1	16.9			85	44	1.8	0.0	1.8	0
3	3.0	-9.4	-3.2	21.2			82	33	0.0	0.2	0.2	TR
4	-0.3	-9.2	-4.8	22.8			74	47	0.0	TR	TR	TR
5	4.2	-10.0	-2.9	20.9			75	34	0.0	0.0	0.0	TR
6	7.5	-9.0	-0.8	18.8			74	38	0.0	0.0	0.0	0
7	14.1	-2.3	5.9	12.1	0.9		61	25	0.0	0.0	0.0	0
8	22.6	-4.2	9.2	8.8	4.2		76	19	0.0	0.0	0.0	0
9	13.2	1.3	7.3	10.7	2.3		72	45	0.0	0.0	0.0	0
10	14.9	-2.8	6.1	11.9	1.1		84	44	0.0	0.0	0.0	0
11	7.2	-1.1	3.1	14.9			87	70	0.0	0.0	0.0	0
12	15.2	-5.3	5.0	13.0			89	47	0.0	0.0	0.0	0
13	13.5	-5.2	4.2	13.8			88	41	0.0	0.0	0.0	0
14	7.3	-1.1	3.1	14.9			94	54	1.0	0.0	1.0	0
15	12.9	-6.3	3.3	14.7			90	48	0.0	0.0	0.0	0
16	15.5	-3.7	5.9	12.1	0.9		82	34	0.0	0.0	0.0	0
17	14.1	-5.3	4.4	13.6			83	41	0.0	0.0	0.0	0
18	16.2	0.7	8.5	9.5	3.5		72	38	TR	0.0	TR	0
19	10.8	-4.2	3.3	14.7			75	37	0.0	0.0	0.0	0
20	9.7	-0.7	4.5	13.5			71	47	0.0	0.0	0.0	0
21	10.2	-4.0	3.1	14.9			72	32	TR	0.0	TR	0
22	14.8	-7.0	3.9	14.1			62	28	0.0	0.0	0.0	0
23	19.0	0.2	9.6	8.4	4.6		73	35	0.0	0.0	0.0	0
24	14.1	-1.2	6.5	11.5	1.5		77	48	0.0	0.0	0.0	0
25	10.0	-0.1	5.0	13.0			85	66	TR	0.0	TR	0
26	14.1	2.2	8.2	9.8	3.2		87	48	TR	0.0	TR	0
27	13.8	2.7	8.3	9.7	3.3		84	52	0.0	0.0	0.0	0
28	4.1	-6.4	-1.2	19.2			99	81	0.0	0.0	0.0	0
29	6.4	-0.3	3.1	14.9			92	71	0.0	0.0	0.0	0
30	10.4	-5.1	2.7	15.3			89	53	0.0	0.0	0.0	0
31	8.4	-8.7	-0.1	18.1			82	42	0.0	0.0	0.0	0
TOTAL				442.1	25.5	0.0			3.8	0.2	4.0	totale
MEAN	11.1	-3.6	3.8				81	45				moyenne
NORMAL	11.3	-2.2	4.6	416.9	54.2	0.0			10.2	7.8	17.7	nomale

NOTE/AVIS:

1. Climatological Day / Journee Climatolooque 23 01 MST - 23 00 MST

2. 30 Year Normals / Normales duree 30 ans.

3. TR - Trace

EDMONTON INTL ARPRT, AB.

MONTH/MOIS: OCTOBER/octobre 2000

DRYBULB TEMPERATURES / TEMPERATURES DU THERMOMETRE SEC

DATE	HOUR / HEURE																							
	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	-20	-14	-7	-20	-20	-35	-34	-33	-7	44	83	90	107	101	96	100	69	72	50	42	40	39	17	13
2	28	24	24	19	11	5	-3	-11	-6	1	14	19	31	36	43	39	39	26	11	-5	-2	-15	-22	-27
3	-35	-37	-36	-38	-72	-72	-91	-92	-40	-18	1	5	17	23	24	28	28	18	13	9	-1	-16	-25	-28
4	-29	-28	-29	-36	-43	-60	-72	-84	-55	-40	-28	-26	-17	-26	-27	-21	-14	-10	-31	-65	-81	-68	-75	-79
5	-88	-87	-92	-83	-85	-87	-88	-95	-65	-37	-14	5	23	27	35	35	36	27	10	-24	-74	-68	-86	-82
6	-80	-75	-79	-84	-83	-76	-68	-66	-55	-25	12	34	48	62	69	70	65	56	38	19	13	11	6	-1
7	-3	-3	-3	-8	-15	-16	-20	-21	-8	11	45	73	99	116	134	138	134	120	89	72	54	51	56	51
8	51	37	24	11	-23	-16	-35	-37	1	48	104	139	176	191	208	219	220	180	118	84	73	30	45	62
9	30	42	41	35	29	58	40	40	34	57	77	87	98	111	123	131	121	102	68	48	37	46	42	13
10	5	-3	-11	-15	-18	-16	-14	-6	11	42	67	88	107	129	141	147	137	116	96	84	73	62	43	54
11	55	62	66	57	47	30	30	36	40	47	48	50	53	56	57	61	69	66	26	1	18	-4	-8	5
12	-1	-7	-24	-24	-29	-32	-40	-39	-33	18	56	89	117	137	139	146	146	118	98	91	80	53	64	55
13	41	7	0	-5	-27	-27	-29	-40	13	60	79	97	103	104	128	132	131	113	67	40	39	61	70	60
14	56	51	40	40	38	41	28	30	34	48	65	70	66	61	62	125	66	66	62	45	27	9	-6	-8
15	-29	-22	-40	-58	-50	-54	-57	-61	-43	1	55	85	108	111	125	125	128	108	72	70	67	62	58	50
16	47	18	19	3	3	-2	-34	3	4	15	83	108	132	129	142	144	131	106	93	35	84	3	-16	-30
17	-20	-28	-25	-41	-45	-32	-32	-30	-11	35	62	98	113	121	128	133	128	93	81	58	85	104	104	84
18	74	62	57	66	47	40	55	70	93	96	70	142	146	138	143	154	153	125	71	58	35	39	46	23
19	19	-2	-28	-18	-25	3	3	-15	-15	55	75	91	85	99	106	104	96	75	30	-7	-25	0	-6	-5
20	-1	11	11	12	9	10	8	4	11	24	33	55	66	73	80	89	95	96	94	89	87	85	62	39
21	42	43	41	48	47	49	49	48	50	55	56	63	80	94	98	99	145	115	73	54	45	80	58	36
22	-38	-31	-49	-56	-38	-39	-45	-25	-12	17	58	90	116	135	137	138	174	142	73	32	-12	-19	-34	-19
23	13	36	29	26	18	26	4	29	35	57	119	159	172	184	182	182	134	110	78	79	79	65	30	15
24	-1	1	30	31	36	32	20	15	11	44	77	103	113	125	132	137	94	76	93	96	79	39	52	56
25	51	34	14	30	4	14	10	29	32	44	59	70	85	85	90	95	130	118	53	31	28	90	42	43
26	42	45	46	45	26	27	23	36	43	45	63	84	98	117	127	141	126	96	106	99	94	40	88	80
27	73	63	57	50	48	44	40	31	27	40	58	86	105	124	133	134	32	126	60	48	42	19	44	39
28	25	21	8	-16	-46	-59	-43	-18	0	9	19	24	25	25	28	28	50	32	26	23	23	19	17	19
29	20	19	24	30	30	33	31	37	43	47	49	48	48	53	57	62	102	47	32	34	34	15	-2	10
30	4	-1	-2	-18	-18	-48	-31	-35	-17	-14	11	41	66	82	90	98	81	50	16	16	10	-14	-21	-12
31	-26	4	-28	-35	-40	-46	-61	-75	-36	-36	-65	34	46	61	68	83	61	49	8	8	3	-11	-16	-12

NOTE/AVIS:
1. Unit = 0.1 C   1. Unite = 0.1 C
2. No entry = Missing / Pas de aleur - Manquant

248

EDMONTON INTL ARPRT, AB. **MONTH/MOIS: OCTOBER/octobre 2000**

PRECIPITATION OCCURRENCES / EVENEMENT DES PRECIPITATIONS

HOUR / HEURE

DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23
1	RW																							
2		R																						
3																				RW	RW	RW		
4												SW		SW	SW	SW						S	S	S
5																								
6																								
7																								
8																								
9																								
10																								
11																								
12																								
13																								
14													RW	RW	RW	RW								
15																								
16																								
17																								
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21																								
22																								
23																								
24																								
25										RW														
26								RW																
27																								
28																								
29																								
30																								
31																								

NOTE/AVIS:

R = Rain/Pluie	W = Showers/averse de	T = Thunderstorm/orage	L = Drizzle/bruine	Z = Freezing/verglacante
S = Snow/neige	SG = Snow Grains/neige en grains	A = Hail/grele	IP = Ice Pellets/gresil	IC = Ice Crystals/cristaux de glace

WINDS (kmh) / DES VENTS (km/h)

HOUR/DATE	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	Peak Gust Rafale	Hour Heur
1	SW	SW	SSW	SW	SW	SW	SW	SW	S	SW	W	WNW	WSW	WNW	WNW	WSW	NNW	N	NNE	NNW	C	NW	WNW	W	NNW	
1	7	7	7	9	7	6	7	6	4	7	9	11	15	17	6	11	28	6	6	20	0	13	4	9	33	1700
2	WNW	NW	NW	NNW	NNW	NNW	N	NNW	NW	NW	NNW	N	WNW	NW	NNW	NW	NW	NW	WNW	WNW	WNW	WNW	WNW	WNW	NNW	
2	15	13	11	15	13	17	15	11	13	15	22	17	20	22	19	22	26	32	17	11	11	11	13	9	44	1600
3	WNW	WNW	W	WNW	W	W	W	W	W	WNW	WNW	NNW	NW	NNW	WNW	WNW	C	W	WNW	WNW	N	N	N	N	NW	
3	13	11	13	13	7	7	9	9	11	13	22	22	22	19	17	11	13	0	4	9	11	9	13	17	33	1200
4	N	N	N	NNW	NW	NW	WNW	C	W	WNW	WNW	NW	NW	NW	NW	NW	NW	NW	W	W	WSW	W	WSW		NW	
4	15	17	15	11	13	13	6	0	11	19	20	20	22	24	28	19	13	19	7	7	7	7	7	7	37	1400
5	W	WSW	W	W	W	W	W	WSW	W	WNW	WNW	NW	WNW	WNW	W	W	W	NNW	C	C	S	SE	SSE	S	S	
5	7	6	6	11	11	9	6	4	13	11	11	11	11	15	6	13	7	7	0	6	4	7	9		7	
6	S	S	S	S	S	S	S	SSE	S	S	S	SSE	SSE	S	SSE	SSE	S	SSE	SSE	SE	SSE	SSE	SSE	SSE	SSE	
6	11	11	13	11	13	11	13	15	13	11	13	22	22	22	28	24	24	22	28	20	24	26	28	33	41	2300
7	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	SSE	S	SSE	SSE	SSE	SSE	S	SSE	SE	SE	SE	SE	SSE	SSE	SSE	SSE	
7	24	26	24	26	19	24	22	20	26	22	26	22	28	26	30	26	24	17	13	20	15	20	20	20	37	100
8	SSE	S	S	S	SE	S	S	SE	S	S	C	W	C	WSW	WNW	NW	NW	WNW	C	C	E	ESE	S	SSW	SSE	
8	15	13	11	9	13	7	7	9	6	7	0	9	0	9	11	9	9	4	0	0	11	7	9	9	9	
9	SE	SE	SE	S	W	SW	WSW	NW	C	C	WNW	N	N	NNW	NW	NNW	NNW	NW	WNW	NNW	WSW	NW	C	C		
9	9	11	9	6	9	6	4	0	0	0	9	9	9	4	9	9	9	6	4	7	11	4	0	0		
10	WNW	WSW	SSW	WNW	C	SW	C	WNW	W	WNW	W	WNW	NW	NW	NW	NNW	NNW	NW	NNW	NW	NW	NW	NW	NW		
10	6	4	7	4	0	6	0	4	6	6	13	13	17	17	17	15	17	20	17	15	17	20	17	13		
11	WNW	NW	NW	NW	WNW	WNW	NW	WNW	WNW	NNW	NNE	WNW	NNW	SSE	WSW	W	S	SSE	SSE	SSE	S	S	S	S	S	
11	19	15	17	19	19	11	7	9	13	7	6	7	6	7	6	4	9	7	11	9	11	13	9	13		
12	S	S	SSE	S	S	S	S	C	C	SSW	C	W	WSW	N	N	ENE	NNE	N	N	NNE	N	C	ESE	SE	SE	
12	15	11	9	9	9	9	6	0	0	6	11	4	7	4	4	7	11	6	9	7	0	6	9	6	0	
13	E	C	ESE	C	C	N	C	C	E	SE	SE	SE	SSE	SE	SSE	SE	SE	ESE	ESE	SE	SE	SE	SSE	SSE	SSE	
13	4	0	7	0	4	0	4	0	4	11	17	17	19	17	17	15	13	13	17	19	11	13	15	15	15	
14	SSE	SSE	SSE	SSE	SSE	SSE	S	S	S	SSW	SSW	N	NNE	NW	NW	NW	C	C	SSW	SW	SSW	SSW	SSW	S	S	
14	15	9	6	13	9	15	11	11	17	9	7	13	13	9	9	4	0	0	6	4	9	7	9	11	11	
15	SSW	S	SSW	S	C	S	S	S	S	SSW	S	S	S	S	S	S	S	SSE	SSE	SSE	S	S	S		S	
15	6	7	6	4	0	4	4	15	4	6	6	13	17	15	17	17	17	13	13	19	15	15	17	13	13	
16	S	S	SW	SSW	SW	SW	SW	SSW	SSW	SSE	S	S	S	SE	ENE	NNW	N	N	N	C	S	C	WSW			
16	9	9	9	6	7	7	11	13	7	6	11	7	9	11	6	6	15	13	11	4	0	7	0	6		
17	S	S	SSW	SSW	C	C	S	C	C	C	SE	SE	SSE	SSE	SE	SE	SE	ESE	E	ESE	ESE	SE	SE	SE	SE	
17	7	7	9	6	0	0	4	0	0	6	11	26	24	19	22	24	20	19	15	19	19	24	24	17	33	2300
18	SE	ESE	SSE	SSW	S	SSW	S	S	SSW	WSW	N	WNW	WNW	WNW	W	W	W	SW	SW	W	W	W	W	SW	WNW	
18	11	11	13	11	9	7	15	7	17	13	6	17	30	24	13	15	13	9	6	13	11	17	13	13	41	1300
19	WSW	SW	WNW	SSW	SW	WSW	W	W	SW	W	NW	WNW	WNW	WNW	NW	NNW	NNW	N	NNE	C	SSE	ESE	ESE	ESE	NW	
19	11	7	4	15	11	13	13	11	13	17	20	33	26	32	26	17	15	13	4	0	6	20	19	20	48	1300
20	ESE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	ESE	ESE	ESE	ESE	ESE	E	ESE	SE	WNW	WSW		SE	
20	20	26	28	33	30	37	33	35	33	41	32	32	35	28	28	28	28	20	15	11	20	13	4	6	50	1000
21	W	WNW	WNW	NW	NW	WNW	WNW	WNW	WNW	WNW	WNW	NW	NW	NW	NW	NW	NW	NW	W	W	WSW	W	W		NW	
21	13	19	20	32	24	19	17	17	19	28	26	24	32	32	37	30	22	22	17	11	13	13	13	13	50	1500
22	WSW	SW	SW	SSW	S	S	S	S	S	S	SSW	SSW	WSW	WSW	S	S	S	S	S	S	SSW	S	C		SSW	
22	9	11	7	15	13	17	17	20	20	20	24	30	20	22	22	17	15	17	15	17	9	0			33	1200
23	S	C	C	S	S	C	C	S	S	S	SSW	W	W	E	NNW	W	E	E	ESE	SSE	SE	E	ESE	ESE		
23	4	0	0	7	4	0	0	9	11	7	9	11	6	6	6	4	4	6	11	9	4	7	7	7		
24	SE	SW	ESE	NW	C	SSW	WNW	C	W	WNW	N	N	NNW	N	NNE	NNE	NNE	NNE	N	NNE	N	N	N	N		
24	11	6	6	11	0	7	6	0	4	6	15	11	11	19	17	13	17	9	13	11	13	13	7	9		
25	NW	C	NW	C	SSW	NW	C	C	C	C	NNW	ENE	C	NE	NE	ENE	NE	NE	NE	ENE	NE	NE	NNE	NE		
25	4	0	4	0	4	6	0	0	0	0	4	4	0	7	7	13	13	13	11	9	7	9	6	6		
26	NE	ENE	E	E	SE	ESE	SE	ESE	ESE	ESE	SE	SE	SE	SE	SE	SE	SSE	SE	SE	SSE	SSE	SSE	SSE	SE	SE	
26	11	11	7	7	6	11	13	19	24	26	26	33	30	35	33	32	32	39	32	35	32	33	35	30	54	1600
27	SSE	SSE	SSE	SSE	SSE	SE	SSE	SE	SSE	SSE	S	S	S	S	S	SE	S	SE	SE	E	E	E	SE	SE	SSE	
27	39	37	39	32	30	26	30	33	28	28	26	22	26	19	19	15	11	17	17	7	13	15	17		54	400
28	ESE	ESE	SW	C	NW	SSW	S	W	WNW	W	WSW	WNW	W	C	C	E	NE	N	N	NNE	NNE	N	N	NW	NW	
28	13	13	4	0	4	4	7	6	6	11	15	6	9	0	0	6	9	6	7	11	7	7	9	7	7	
29	NNW	NW	WNW	WNW	W	WNW	NW	W	NW	NW	NW	NW	NW	NNW	NNW	NW	NW	WNW	WNW	NNW	C	W	WNW		NW	
29	7	9	15	15	17	19	13	7	15	20	13	17	20	22	13	11	9	9	6	4	0	6	7		33	700
30	WNW	WNW	WNW	NW	C	N	S	SSE	N	N	SE	SSE	C	C	S	S	S	S	SE	SSE	S	S	S			
30	6	7	7	6	0	4	6	6	4	7	6	4	0	0	9	9	7	4	9	9	11	13	15	13		
31	SE	S	S	S	S	S	S	S	SE	S	SW	W	WNW	WNW	WNW	NW	WNW	W	W	W	W	W	W	WNW		
31	15	17	11	19	15	13	7	7	9	7	7	6	7	7	9	7	6	7	4	7	6	6	4	9		

DATE	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	
Pdir	SW	NW	WNW	NW	W	S	SSE	S	NW	NW	WNW	S	SE	SSE	S	
Avg V	9	16	12	14	8	20	22	8	6	11	11	6	10	9	11	
dir 2		WNW	W						NNW					SSW		

DATE	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	
Pdir	S	SE	W	WNW	SE	WNW	S	S	N	NE	SSE	SSE	N	WNW	S	S	
Avg V	8	13	13	15	26	21	16	6	10	5	25	23	7	12	7	9	
dir 2											SE						

NOTE/AVIS: Pdir = Prevailing direcation/Direction dominante

                dir2 = 2nd Prevailing direction

                * = indicates/indique < 24 hrs and/et >= 18hrs

8.4 Raw Chemical Composition Data

Sample Description

Data #	1	2	3	4	5	6	7	8	9	10
Sample #	3	4	5 and 6	7	8	9	10	11	12	13
Date (period ending at noon)	2-Aug-00	3-Aug-00	4-Aug-00	5-Aug-00	6-Aug-00	7-Aug-00	8-Aug-00	9-Aug-00	10-Aug-00	11-Aug-00
Replicated?			Yes							
Replicate Used?			Yes							
Sampling Duration (hr)	24	5	24	24	24	24	24	25	24	23
Concentration (μg/m³)	12.8	6.2	11.2	16.6	14.1	8.1	7.8	8.2	10.6	10.3
# of Particles Analyzed	10	10	20	10	10	10	10	10	10	10
# of Particles Averaged	10	10	20	10	10	10	10	10	10	10

Elemental Composition (%)

Elements	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Si	44.48	68.94	53.473	48.753	46.84	37.444	49.077	70.639	54.336	72.614
Ca	33.16	7.46	7.9685	27.5	25.164	22.759	6.656	4.848	24.277	6.855
Fe	3.75	4.66	5.4175	5.023	10.419	4.651	5.29	9.769	7.117	4.83
Al	8.81	11.02	11.3315	7.528	11.258	13.362	10.389	9.653	7.302	5.463
K	3.24	1.52	4.2145	4.822	2.176	17.298	10.687	2.117	2.523	5.084
Na	0.02	0.25	1.6815	0.341	0.444	0.266	0.1	0.732	0.238	0.315
Mg	1.38	0.66	2.392	3.691	0.873	0.661	1.139	0.485	1.568	0.999
Mn	0.50	0.36	0.405	0.433	0.495	0.873	0.535	0.135	0.375	0.626
Cl	0.56	0.22	2.3995	0.302	0.61	0.338	0.321	0.087	0.252	0.65
S	0	1.07	5.083	0	0	0.044	7.8	0	0	0.082
P	1.93	0	0	0	0	0	0	0	0	0
Ti	0.70	0.62	0.619	0.567	0.2	0.294	6.087	0.404	0.345	0.329
V	0.14	0.19	0.5355	0.083	0.09	0.143	0.416	0.143	0.051	0.23
Pb	0.54	1.07	1.0435	0.276	0.286	0.584	0.096	0.042	0.24	0.252
Cr	0.18	0.342	0.5265	0.087	0.365	0.179	0.058	0.098	0.413	0.265
Ni	0.06	0.237	0.8315	0.104	0.119	0.329	0.652	0.197	0.523	0.495
Cu	0.38	0.574	0.4255	0.286	0.04	0.606	0.281	0.402	0.201	0.386
Zn	0.19	0.521	0.819	0.068	0.294	0.123	0.164	0.185	0.05	0.084
As	0	0.297	0.934	0.138	0.324	0.065	0.249	0.064	0.177	0.457
Biological (Ratio)	0.60	0.8	1.1	0.8	0.8	3.6	2.4	4.7	0.4	2.2

253

Sample Description

Data #	11	12	13	14	15	16	17	18	19	20
Sample #	14	16	17	18 and 19	20	21	22	23	24	25
Date (period ending at noon)	12-Aug-00	13-Aug-00	14-Aug-00	15-Aug-00	16-Aug-00	17-Aug-00	18-Aug-00	19-Aug-00	20-Aug-00	21-Aug-00
Replicated?				Yes						
Replicate Used?				Yes						
Sampling Duration (hr)	24	24	24	24	24	24	24	24	24	24
Concentration ($\mu g/m^3$)	7.9	7.1	5.1	7.2	11.7	8.4	16.7	20.9	8.3	7.2
# of Particles Analyzed	10	10	10	20	10	10	10	10	10	10
# of Particles Averaged	10	10	10	20	10	10	10	10	10	10

Elemental Composition (%)

Elements	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Si	35.582	32.166	28.341	53.88	61.249	48.838	48.113	52.269	69.949	59.72
Ca	30.916	33.427	15.51	12.258	5.261	10.913	15.782	16.011	5.073	10.388
Fe	6.037	9.063	6.439	11.393	6.377	11.795	10.958	7.093	6.984	6.657
Al	9.453	12.073	7.64	11.4685	7.986	7.98	14.637	12.098	11.12	11.681
K	9.704	3.6	4.994	4.3425	2.599	5.039	4.441	6.895	2.308	4.299
Na	0.287	0	7.994	0.2205	0.759	0.853	1.098	0.232	1.502	0.647
Mg	2.378	4.825	0.77	1.0005	0.78	0.419	1.27	0.97	0.45	2.558
Mn	0.31	0.635	0.674	0.544	0.307	2.146	0.408	0.432	0.549	0.29
Cl	0.8	0.812	23.988	0.156	0.684	0.228	0.427	0.304	0.107	0.391
S	1.583	0	0	0	0	7.804	0	0	0	0.591
P	0	0	0	0.975	0	0	0	0	0	0
Ti	0.389	0.764	0.636	0.619	1.389	0.48	0.342	1.098	0.569	0.576
V	0.317	0.187	0.717	0.11	0.587	0.342	0.262	0.408	0.135	0.308
Pb	0.051	0.675	0.19	1.1545	7.807	0.453	0.372	0.092	0.111	0.31
Cr	0.27	0.194	0.055	0.294	0.42	0.109	0.304	0.164	0.091	0.112
Ni	0.404	0.523	0.322	0.3815	0.627	0.54	0.471	0.574	0.208	0.444
Cu	0.38	0.242	0.348	0.5765	0.75	0.944	0.64	0.521	0.14	0.792
Zn	0.504	0.418	0.764	0.398	0.362	0.283	0.368	0.341	0.266	0.159
As	0.566	0.416	0.618	0.26	2.079	0.8	0.113	0.522	0.454	0.083
Biological (Ratio)	3.1	3.7	1.8	0.7	0.7	0.6	0.6	0.4	2.8	2.4

254

Sample Description

Data #	21	22	23	24	25	26	27	28	29	30
Sample #	26 and 27	28	32	33 and 34	35	36	37	38	39	40
Date (period ending at noon)	22-Aug-00	23-Aug-00	4-Oct-00	5-Oct-00	6-Oct-00	7-Oct-00	8-Oct-00	9-Oct-00	10-Oct-00	11-Oct-00
Replicated?	Yes			Yes						
Replicate Used?	No			No						
Sampling Duration (hr)	24	23	24	24	23	24	24	24	24	24
Concentration (µg/m³)	14.7	23.5	3.6	3.8	5.6	4.6	16.3	19.7	18.5	10
# of Particles Analyzed	20	10	10	20	10	10	10	10	10	10
# of Particles Averaged	10	10	10	10	10	10	10	10	10	10

Elemental Composition (%)

Elements	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Si	66.022	57.65	65.764	48.986	41.391	32.469	42.29	45.809	57.861	52.473
Ca	5.786	12.707	8.652	19.563	32.978	44.574	17.071	11.26	7.341	11.7
Fe	7.048	8.817	12.79	12.996	8.253	6.822	5.775	11.503	12.665	5.043
Al	10.206	11.022	6.778	8.669	6.848	5.435	7.691	10.126	11.591	11.123
K	5.352	4.196	2.083	3.443	3.861	2.139	4.342	9.539	4.446	8.73
Na	0.29	0.444	0.18	0.897	0.84	1.178	7.496	0.213	0.502	5.616
Mg	1.165	1.384	0.759	0.799	0.973	1.999	0.781	1.69	0.858	1.019
Mn	0.404	0.359	0.538	0.506	0.391	0.744	0.524	1.754	1.574	0.324
Cl	0.604	0.278	0.517	0.368	0.349	0.819	0.33	2.336	0.422	1.896
S	0	0	0	0	0	0	10.375	0	0	0
P	0	0	0	0	0	0	0	0	0	0
Ti	0.335	0.651	0.302	0.652	0.185	0.914	0.313	0.682	0.587	0.659
V	0.026	0.229	0.091	0.131	0.181	0.163	0.232	0.483	0.234	0.036
Pb	1.322	0.93	0.547	0.73	0.415	0.197	0.486	0.302	0.658	0.507
Cr	0.148	0.268	0.238	0.177	0.321	0.172	0.283	0.714	0.218	0.148
Ni	0.12	0.448	0.589	0.406	0.194	0.732	0.519	0.735	0.481	0.141
Cu	1.1	0.351	0.162	0.52	1.571	0.689	0.602	0.686	0.279	0.256
Zn	0.065	0	0	0.494	1.089	0.404	0.338	0.875	0.121	0.233
As	0	0.25	0	0.69	0.17	0.551	0.532	1.271	0.143	0.136
Biological (Ratio)	0.3	0.1	0.5	0.1	0.3	0.3	0.2	0.4	0.2	0.2

255

Sample Description

Data #	31	32	33	34	35	36	37	38	39	40
Sample #	41	42	43	45	46	47 and 48	49	50	51	52
Date (period ending at noon)	12-Oct-00	13-Oct-00	14-Oct-00	15-Oct-00	16-Oct-00	17-Oct-00	18-Oct-00	19-Oct-00	20-Oct-00	21-Oct-00
Replicate Used?						Yes				
Replicate Used?						Yes				
Sampling Duration (hr)	24	24	24	24	24	24	24	24	24	25
Concentration (µg/m³)	18.1	27.5	27.2	7.8	9.2	13.3	18	9.1	13.8	18.3
# of Particles Analyzed	10	10	10	10	10	20	10	10	10	10
# of Particles Averaged	10	10	10	10	10	20	10	10	10	10

Elemental Composition (%)

Elements	100%	100%	100%	100%	100%	100%	100%	100%	100%	100%
Si	55.79	60.506	61.907	48.179	44.912	52.915	57.222	62.119	61.906	52.319
Ca	23.238	14.031	6.935	8.147	19.311	14.7375	6.797	10.189	13.895	10.638
Fe	6.349	6.869	10.158	14.404	12.297	7.293	13.845	6.917	8.488	9.432
Al	7.296	5.684	11.687	11.751	7.378	11.653	12.259	14.417	7.944	13.788
K	4.206	6.543	4.237	10.185	5.407	7.516	4.728	2.635	3.095	8.778
Na	0.149	2.092	0.059	0.417	0	0.299	0.126	0.728	0	0.519
Mg	0.76	1.255	1.435	2.246	2.207	2.0995	1.226	0.723	1.088	2.102
Mn	0.318	0.143	0.417	0.525	0.53	0.48	1.191	0.118	0.339	0.41
Cl	0.313	0.708	0.214	0.913	0.377	0.379	0.65	0.282	0.426	0.307
S	0	0	0	0	3.786	0	0	0	0	0
P	0	0	0	0	0	0	0	0	0	0
Ti	0.33	0.195	0.43	0.579	0.332	0.8825	0.396	0.474	1.101	0.604
V	0.174	0.167	0.155	0.297	0.847	0.0955	0.244	0.197	0.144	0.276
Pb	0.307	0.216	0.581	0.998	0.212	0.5485	0.193	0.421	0.086	0.383
Cr	0.077	0.102	0.105	0.182	0.087	0.179	0.142	0.094	0.204	0.107
Ni	0.205	0.366	0.455	0.298	0.193	0.397	0.212	0.113	0.142	0.063
Cu	0.201	0.366	0.493	0.375	1.204	0.344	0.37	0.281	0.241	0.041
Zn	0.304	0.498	0.351	0.31	0.906	0.0315	0.224	0.05	0.077	0.046
As	0	0.237	0.382	0.167	0	0.164	0.212	0.249	0.825	0.149
Biological (Ratio)	0.1	0	0.3	0.8	0.1	0.25	0	0.3	0	0.1

256

Sample Description

Data #	41	42	43	44
Sample #	53	54	55 and 56	57
Date (period ending at noon)	22-Oct-00	23-Oct-00	24-Oct-00	25-Oct-00
Replicated?			Yes	
Replicate Used?			Yes	
Sampling Duration (hr)	24	23	24	24
Concentration (µg/m³)	9.1	17.3	32.7	17.3
# of Particles Analyzed	10	10	20	10
# of Particles Averaged	10	10	20	10

Elemental Composition (%)

Elements	100%	100%	100%	100%
Si	60.003	43.029	60.8555	53.026
Ca	11.897	27.576	12.07	14.816
Fe	14.976	12.513	10.5145	7.396
Al	6.136	8.172	7.6395	8.909
K	2.322	4.098	4.295	9.73
Na	0.364	0.152	0	0.405
Mg	0.859	0.564	0.851	1.502
Mn	0.649	1.595	0.6815	0.286
Cl	0.218	0.207	0.419	0.317
S	0.938	0	0	1.086
P	0	0	0	0
Ti	0.212	0.165	0.47	0.651
V	0.116	0.175	0.0885	0.052
Pb	0.584	0.226	0.59	0.336
Cr	0.04	0.239	0.2135	0.136
Ni	0.293	0.354	0.321	0.344
Cu	0.274	0.426	0.5335	0.582
Zn	0.093	0.15	0.3405	0.175
As	0.043	0.38	0.115	0.237
Biological (Ratio)	0	0	0.05	0.2

Total Average Elemental Composition

	Total	August, 2000	October, 2000
	100%	100%	100%
Si	52.77	52.74	52.81
Ca	15.64	15.49	15.79
Fe	8.57	7.25	9.88
Al	9.69	10.16	9.23
K	5.18	5.07	5.29
Na	0.93	0.85	1.01
Mg	1.35	1.45	1.26
Mn	0.59	0.54	0.64
Cl	1.07	1.57	0.58
S	0.91	1.09	0.74
P	0.07	0.13	0.00
Ti	0.66	0.82	0.51
V	0.23	0.26	0.21
Pb	0.62	0.81	0.43
Cr	0.21	0.22	0.19
Ni	0.37	0.39	0.34
Cu	0.47	0.47	0.48
Zn	0.31	0.29	0.32
As	0.35	0.40	0.30
	0.89	1.57	0.20

Elemental Concentration (ng/m³)

Data #	Si	Ca	Fe	Al	K	Na	Mg
1	5692.8	4243.968	479.872	1127.296	414.976	2.048	176.256
2	4274.156	462.458	288.982	683.302	94.426	15.438	40.982
3	5988.976	892.472	606.76	1269.128	472.024	188.328	267.904
4	8092.998	4565	833.818	1249.648	800.452	56.606	612.706
5	6604.44	3548.124	1469.079	1587.378	306.816	62.604	123.093
6	3032.964	1843.479	376.731	1082.322	1401.138	21.546	53.541
7	3828.006	519.168	412.62	810.342	833.586	7.8	88.842
8	5792.398	397.536	801.058	791.546	173.594	60.024	39.77
9	5759.616	2573.362	754.402	774.012	267.438	25.228	166.208
10	7479.242	706.065	497.49	562.689	523.652	32.445	102.897
11	2810.978	2442.364	476.923	746.787	766.616	22.673	187.862
12	2283.786	2373.317	643.473	857.183	255.6	0	342.575
13	1445.391	791.01	328.389	389.64	254.694	407.694	39.27
14	3879.36	882.576	820.296	825.732	312.66	15.876	72.036
15	7166.133	615.537	746.109	934.362	304.083	88.803	91.26
16	4102.392	916.692	990.78	670.32	423.276	71.652	35.196
17	8034.871	2635.594	1829.986	2444.379	741.647	183.366	212.09
18	10924.221	3346.299	1482.437	2528.482	1441.055	48.488	202.73
19	5805.767	421.059	579.672	922.96	191.564	124.666	37.35
20	4299.84	747.936	479.304	841.032	309.528	46.584	184.176
21	9705.234	850.542	1036.056	1500.282	786.744	42.63	171.255
22	13547.75	2986.145	2071.995	2590.17	986.06	104.34	325.24
23	2367.504	311.472	460.44	244.008	74.988	6.48	27.324
24	1861.468	743.394	493.848	329.422	130.834	34.086	30.362
25	2317.896	1846.768	462.168	383.488	216.216	47.04	54.488
26	1493.574	2050.404	313.812	250.01	98.394	54.188	91.954
27	6893.27	2782.573	941.325	1253.633	707.746	1221.848	127.303
28	9024.373	2218.22	2266.091	1994.822	1879.183	41.961	332.93
29	10704.285	1358.085	2343.025	2144.335	822.51	92.87	158.73
30	5247.3	1170	504.3	1112.3	873	561.6	101.9
31	10097.99	4206.078	1149.169	1320.576	761.286	26.969	137.56
32	16639.15	3858.525	1888.975	1563.1	1799.325	575.3	345.125
33	16838.704	1886.32	2762.976	3178.864	1152.464	16.048	390.32
34	3757.962	635.466	1123.512	916.578	794.43	32.526	175.188
35	4131.904	1776.612	1131.324	678.776	497.444	0	203.044
36	7037.695	1960.0875	969.969	1549.849	999.628	39.767	279.2335
37	10299.96	1223.46	2492.1	2206.62	851.04	22.68	220.68
38	5652.829	927.199	629.447	1311.947	239.785	66.248	65.793
39	8543.028	1917.51	1171.344	1096.272	427.11	0	150.144
40	9574.377	1946.754	1726.056	2523.204	1606.374	94.977	384.666
41	5460.273	1082.627	1362.816	558.376	211.302	33.124	78.169
42	7444.017	4770.648	2164.749	1413.756	708.954	26.296	97.572
43	19899.749	3946.89	3438.2415	2498.1165	1404.465	0	278.277
44	9173.498	2563.168	1279.508	1541.257	1683.29	70.065	259.846
Count	44	44	44	44	44	40	44
Mean	6932.09	1907.79	1115.487	1255.87	681.85	106.6571	171.9056
Std Dev	4145.57	1272.03	754.7502	724.697	497.086	214.3009	124.9131

Data #	Mn	Cl	S	P	Ti	V	Pb
1	63.36	71.04	0	247.552	89.6	18.432	69.12
2	22.196	13.392	66.278	0	38.192	11.47	66.03
3	45.36	268.744	569.296	0	69.328	59.976	116.872
4	71.878	50.132	0	0	94.122	13.778	45.816
5	69.795	86.01	0	0	28.2	12.69	40.326
6	70.713	27.378	3.564	0	23.814	11.583	47.304
7	41.73	25.038	608.4	0	474.786	32.448	7.488
8	11.07	7.134	0	0	33.128	11.726	3.444
9	39.75	26.712	0	0	36.57	5.406	25.44
10	64.478	66.95	8.446	0	33.887	23.69	25.956
11	24.49	63.2	125.057	0	30.731	25.043	4.029
12	45.085	57.652	0	0	54.244	13.277	47.925
13	34.374	1223.388	0	0	32.436	36.567	9.69
14	39.168	11.232	0	70.2	44.568	7.92	83.124
15	35.919	80.028	0	0	162.513	68.679	913.419
16	180.264	19.152	655.536	0	40.32	28.728	38.052
17	68.136	71.309	0	0	57.114	43.754	62.124
18	90.288	63.536	0	0	229.482	85.272	19.228
19	45.567	8.881	0	0	47.227	11.205	9.213
20	20.88	28.152	42.552	0	41.472	22.176	22.32
21	59.388	88.788	0	0	49.245	3.822	194.334
22	84.365	65.33	0	0	152.985	53.815	218.55
23	19.368	18.612	0	0	10.872	3.276	19.692
24	19.228	13.984	0	0	24.776	4.978	27.74
25	21.896	19.544	0	0	10.36	10.136	23.24
26	34.224	37.674	0	0	42.044	7.498	9.062
27	85.412	53.79	1691.125	0	51.019	37.816	79.218
28	345.538	460.192	0	0	134.354	95.151	59.494
29	291.19	78.07	0	0	108.595	43.29	121.73
30	32.4	189.6	0	0	65.9	3.6	50.7
31	57.558	56.653	0	0	59.73	31.494	55.567
32	39.325	194.7	0	0	53.625	45.925	59.4
33	113.424	58.208	0	0	116.96	42.16	158.032
34	40.95	71.214	0	0	45.162	23.166	77.844
35	48.76	34.684	348.312	0	30.544	77.924	19.504
36	63.84	50.407	0	0	117.3725	12.7015	72.9505
37	214.38	117	0	0	71.28	43.92	34.74
38	10.738	25.662	0	0	43.134	17.927	38.311
39	46.782	58.788	0	0	151.938	19.872	11.868
40	75.03	56.181	0	0	110.532	50.508	70.089
41	59.059	19.838	85.358	0	19.292	10.556	53.144
42	275.935	35.811	0	0	28.545	30.275	39.098
43	222.8505	137.013	0	0	153.69	28.9395	192.93
44	49.478	54.841	187.878	0	112.623	8.996	58.128
Count	44	44	12	2	44	44	44
Mean	77.17317	96.94645	99.81368	7.221636	77.87072	28.44468	77.32467
Std Dev	77.55744	191.097	294.5769	38.5539	78.26299	22.89994	138.7256

Data #	Cr	Ni	Cu	Zn	As	Biological
1	23.552	7.424	48.512	24.576	0	0.6
2	21.204	14.694	35.588	32.302	18.414	0.8
3	58.968	93.128	47.656	91.728	104.608	1.1
4	14.442	17.264	47.476	11.288	22.908	0.8
5	51.465	16.779	5.64	41.454	45.684	0.8
6	14.499	26.649	49.086	9.963	5.265	3.6
7	4.524	50.856	21.918	12.792	19.422	2.4
8	8.036	16.154	32.964	15.17	5.248	4.7
9	43.778	55.438	21.306	5.3	18.762	0.4
10	27.295	50.985	39.758	8.652	47.071	2.2
11	21.33	31.916	30.02	39.816	44.714	3.1
12	13.774	37.133	17.182	29.678	29.536	3.7
13	2.805	16.422	17.748	38.964	31.518	1.8
14	21.168	27.468	41.508	28.656	18.72	0.7
15	49.14	73.359	87.75	42.354	243.243	0.7
16	9.156	45.36	79.296	23.772	67.2	0.6
17	50.768	78.657	106.88	61.456	18.871	0.6
18	34.276	119.966	108.889	71.269	109.098	0.4
19	7.553	17.264	11.62	22.078	37.682	2.8
20	8.064	31.968	57.024	11.448	5.976	2.4
21	21.756	17.64	161.7	9.555	0	0.3
22	62.98	105.28	82.485	0	58.75	0.1
23	8.568	21.204	5.832	0	0	0.5
24	6.726	15.428	19.76	18.772	26.22	0.1
25	17.976	10.864	87.976	60.984	9.52	0.3
26	7.912	33.672	31.694	18.584	25.346	0.3
27	46.129	84.597	98.126	55.094	86.716	0.2
28	140.658	144.795	135.142	172.375	250.387	0.4
29	40.33	88.985	51.615	22.385	26.455	0.2
30	14.8	14.1	25.6	23.3	13.6	0.2
31	13.937	37.105	36.381	55.024	0	0.1
32	28.05	100.65	100.65	136.95	65.175	0
33	28.56	123.76	134.096	95.472	103.904	0.3
34	14.196	23.244	29.25	24.18	13.026	0.8
35	8.004	17.756	110.768	83.352	0	0.1
36	23.807	52.801	45.752	4.1895	21.812	0.25
37	25.56	38.16	66.6	40.32	38.2	0
38	8.554	10.283	25.571	4.55	22.659	0.3
39	28.152	19.596	33.258	10.626	113.85	0
40	19.581	11.529	7.503	8.418	27.267	0.1
41	3.64	26.663	24.934	8.463	3.913	0
42	41.347	61.242	73.698	25.95	65.74	0
43	69.8145	104.967	174.4545	111.3435	37.605	0.05
44	23.528	59.512	100.686	30.275	41.001	0.2
Count	44	44	44	42	39	44
Mean	27.05369	46.65266	58.43983	37.33814	44.2065	0.886364
Std Dev	24.56583	36.37331	42.77297	37.49035	54.40821	1.166458

8.5 SEM Photographs and EDX Spectra
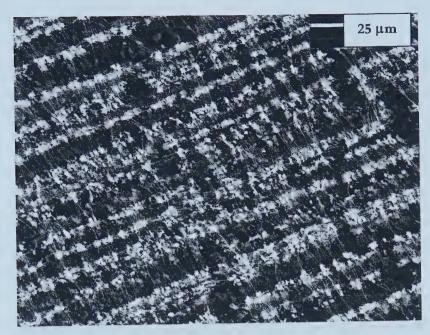
Figure 44. SEM Photograph of an Overview of a Control Blank from the August Sampling Season.
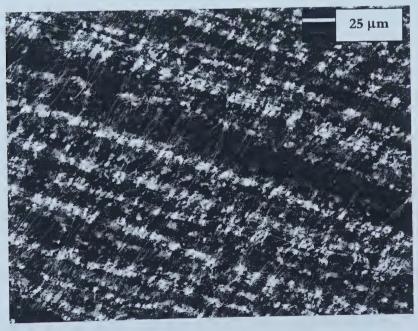
Figure 45. SEM Photograph of an Overview of a Field Blank from the August Sampling Season.

Figure 46. SEM Photograph of an Overview of a Control Blank from the October Sampling Season.
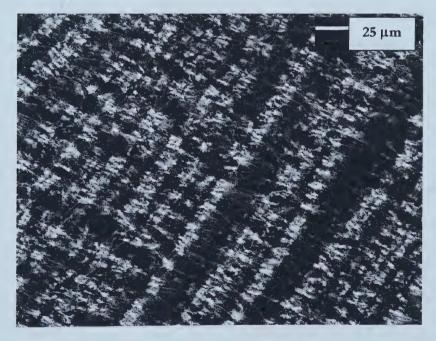
Figure 47. SEM Photograph of an Overview of a Field Blank from the October Sampling Season.

263
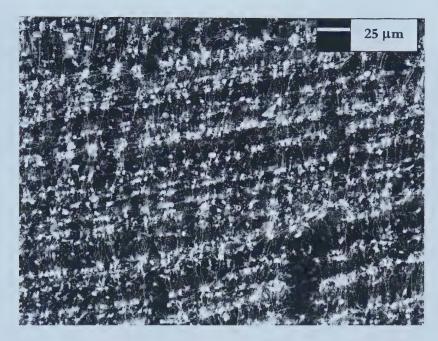
Figure 48. SEM Photograph of an Overview of a Sample (Sample #3) from the August Sampling Season.
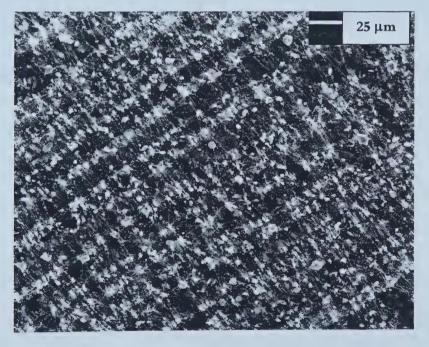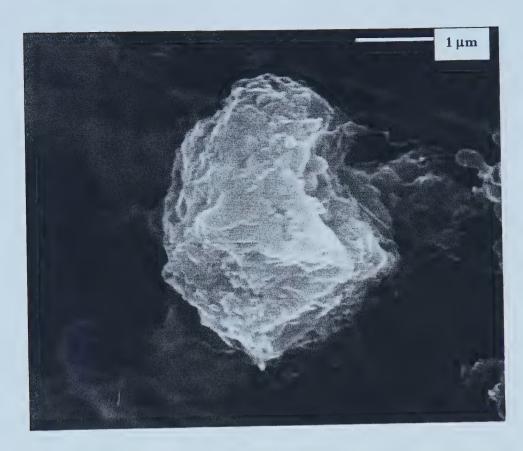
**Figure 49. SEM Photograph of an Overview of a Sample (Sample #42) from the October Sampling Season.**
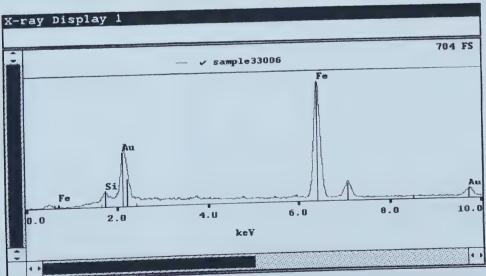
Figure 50. SEM Photograph and Elemental Spectra for an Iron (Rust) Particle.
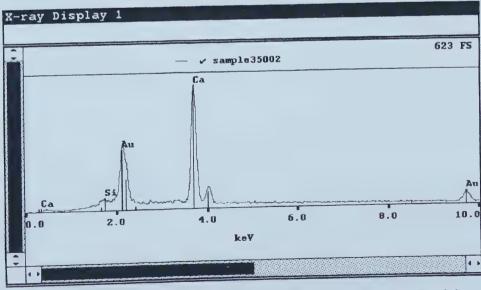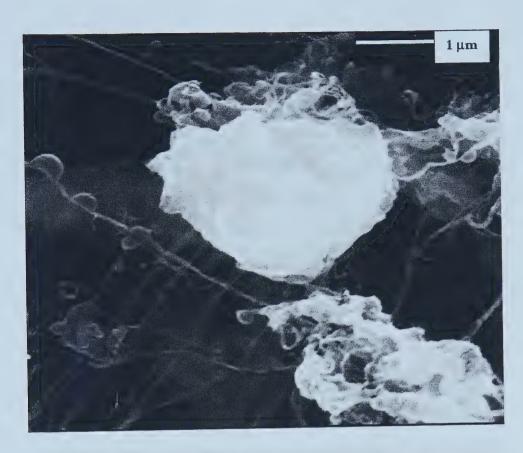
Figure 51. SEM Photograph and Elemental Spectra a Calcium Particle.
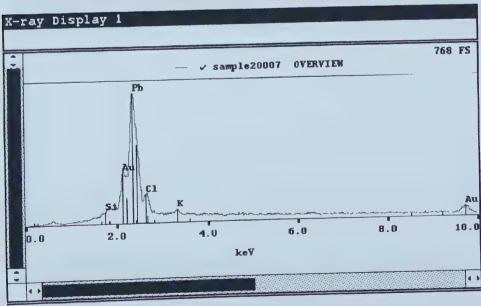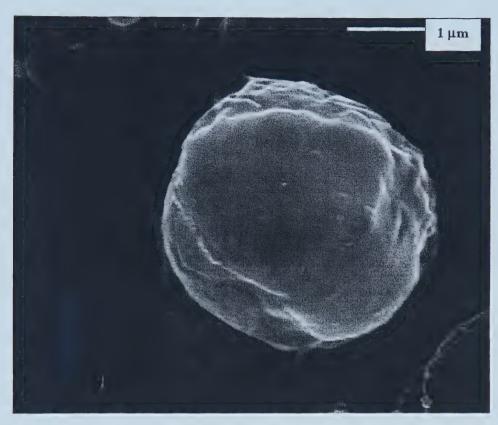
Figure 52. SEM Photograph and Elemental Spectra for a Lead Particle.
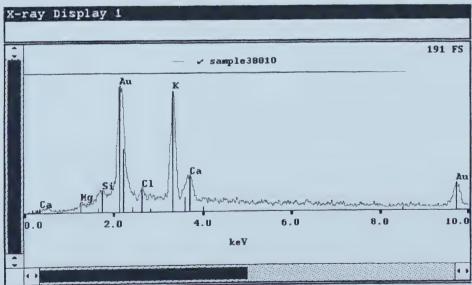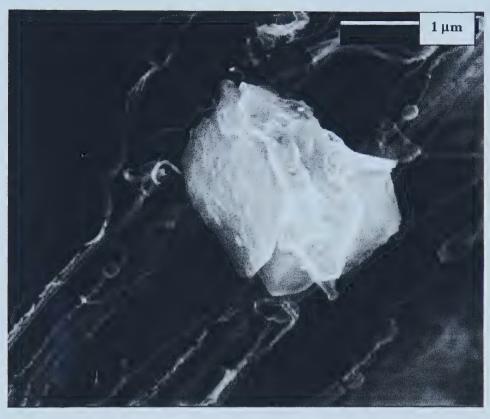
Figure 53. SEM Photograph and Elemental Spectra for a Combustion Particle.
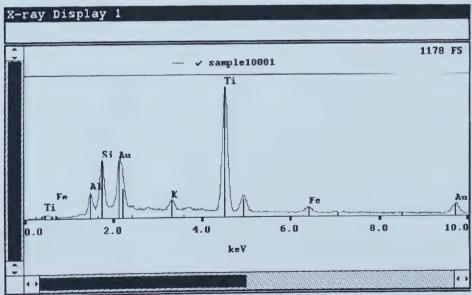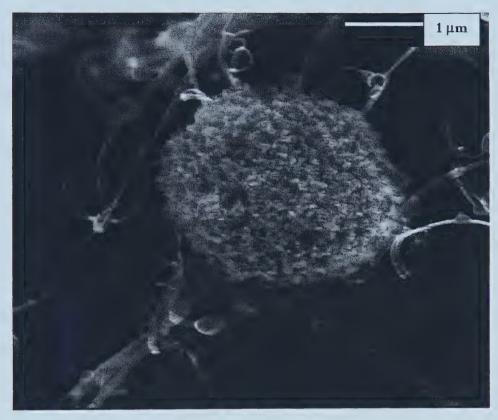
Figure 54. SEM Photograph and Elemental Spectra for a Titanium Particle.
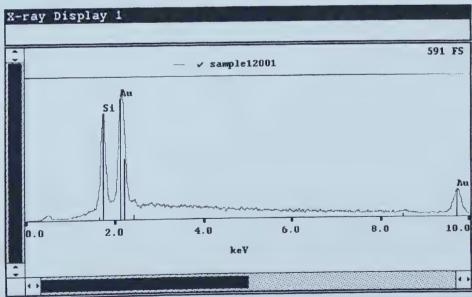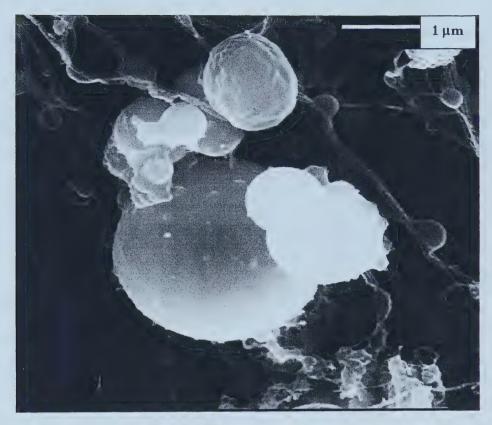
Figure 55. SEM Photograph and Elemental Spectra for a Fibrous Quartz
Particle.
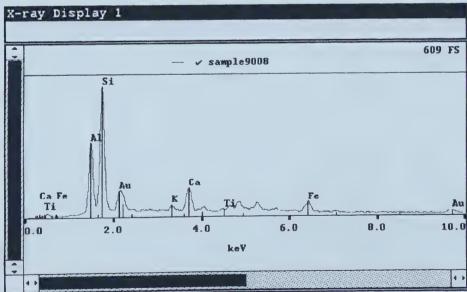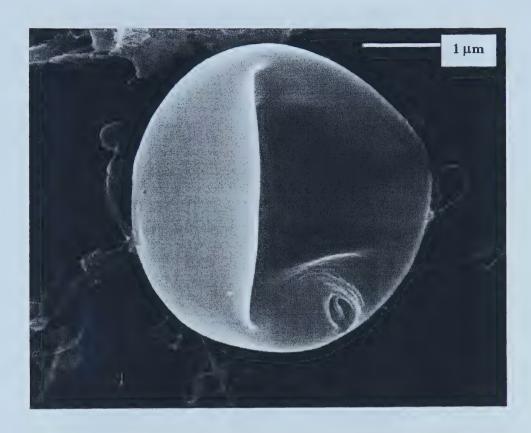
Figure 56. SEM Photograph and Elemental Spectra for a Conglomerate Flyash Particle.
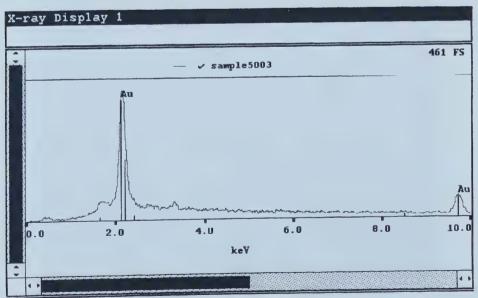
Figure 57. SEM Photograph and Elemental Spectra for a Spore.

Figure 58. SEM Photograph of Plant Debris.
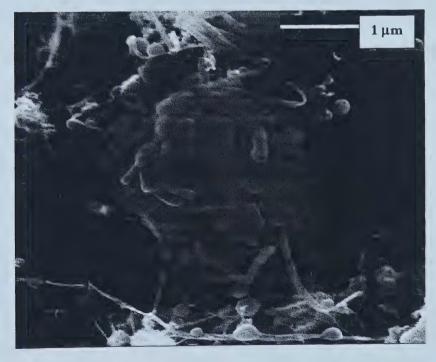
Figure 59. SEM Photograph of Soot Ash.
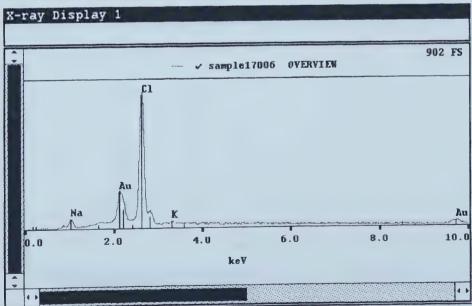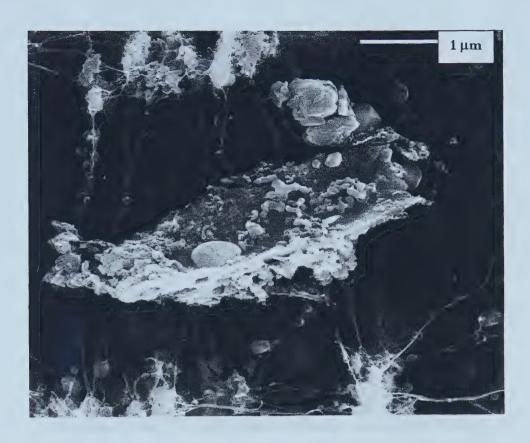
Figure 60. SEM Photograph and Elemental Spectra for a Salt Particle.
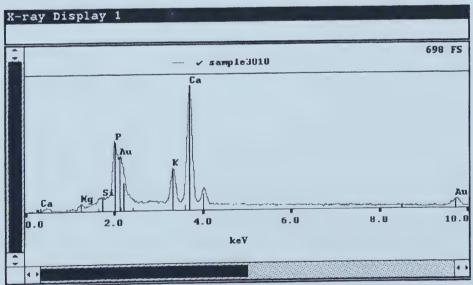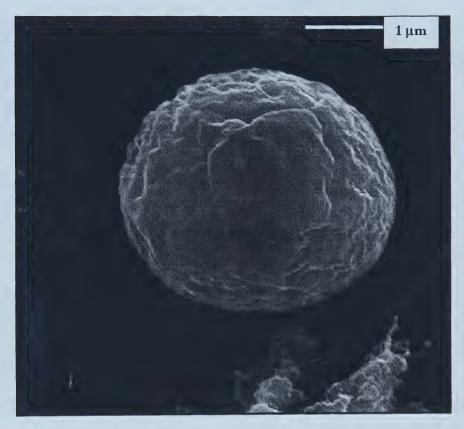
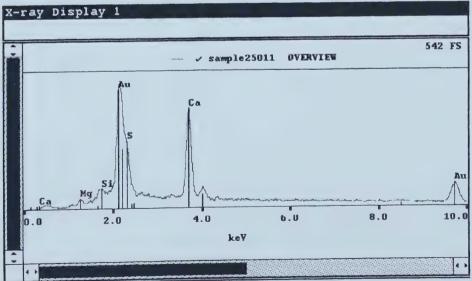Figure 61. SEM Photograph and Elemental Spectra for a Gypsum (Ca/P) Particle.

Figure 62. SEM Photograph and Elemental Spectra for a Combustion (Ca/S) Particle.
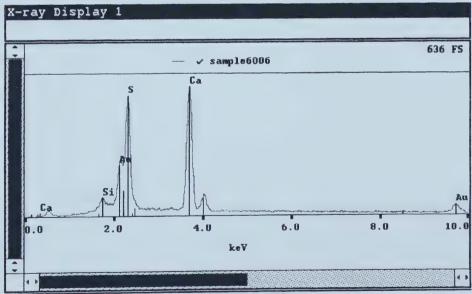
Figure 63. SEM Photograph and Elemental Spectra for a Calcium Sulphate (Ca/S) Particle.
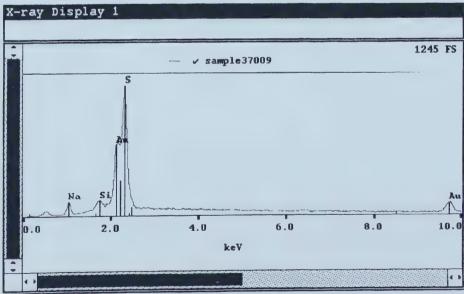
Figure 64. SEM Photograph and Elemental Spectra for a Smooth Sulphur and Sodium Particle.
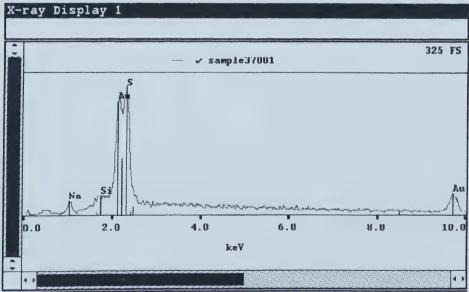
Figure 65. SEM Photograph and Elemental Spectra for a Crystal Sulphur and Sodium Particle.